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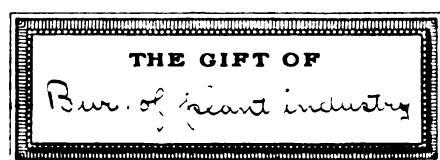
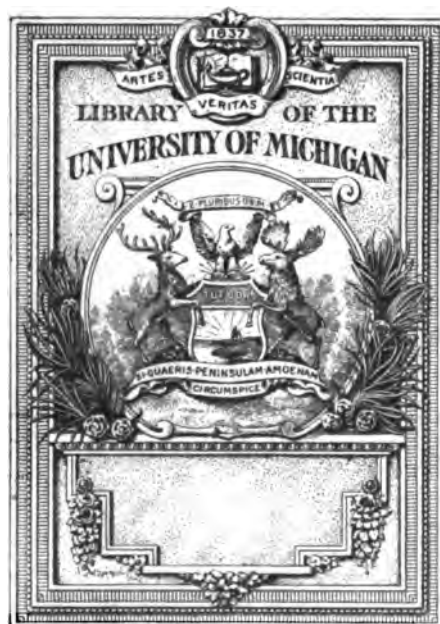
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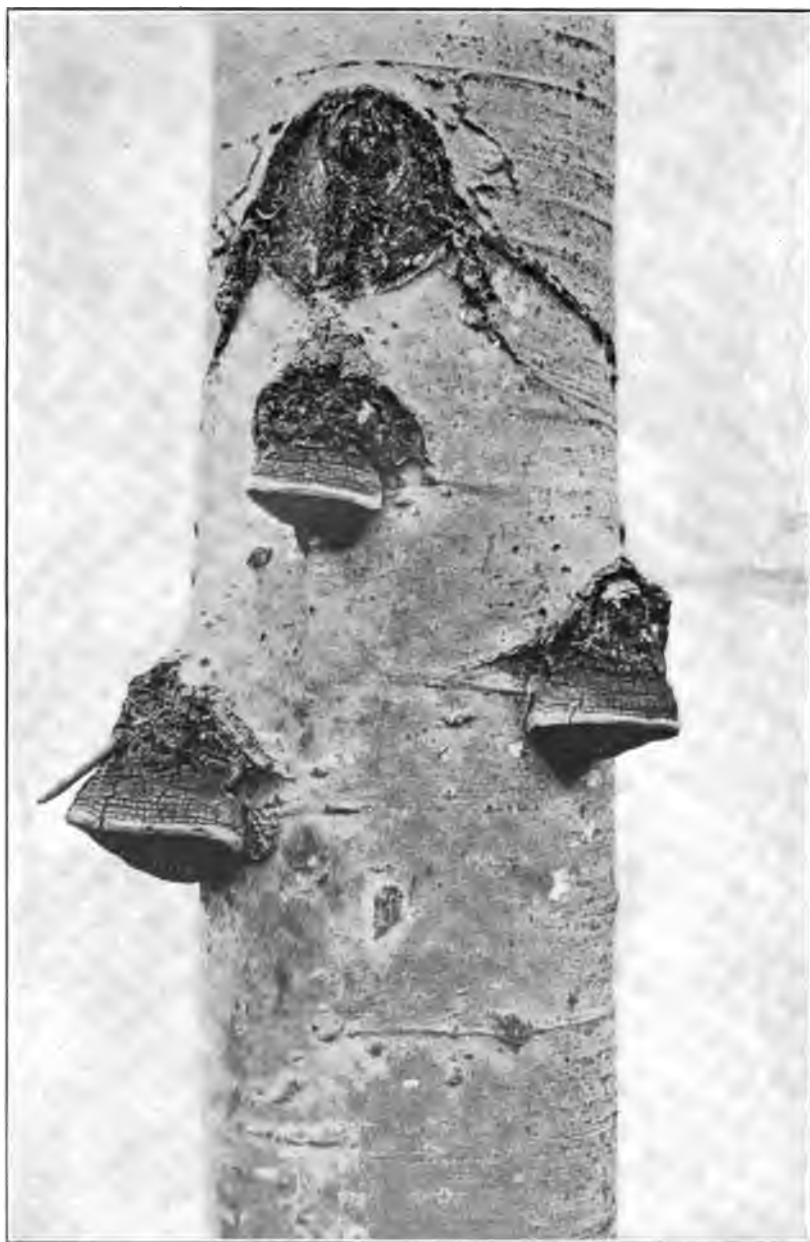
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▲ A LIVING ASPEN TREE WITH SEVERAL SPOROPHORES OF *FOMES IGNARIUS*.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 149.

B. T. GALLOWAY, *Chief of Bureau.*

DISEASES OF DECIDUOUS FOREST TREES.

BY

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,

Washington, D. C., February 12, 1909.

SIR: I have the honor to transmit herewith a paper entitled "Diseases of Deciduous Forest Trees," by Hermann von Schrenk, formerly Expert in Charge of the Mississippi Valley Laboratory of the Bureau of Plant Industry, and Perley Spaulding, Pathologist, Investigations in Forest Pathology.

The paper embodies the results of several years of investigation and gives a general account of the principal diseases of our hardwood forest trees. I recommend that it be published as Bulletin No. 149 of the series of this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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DISEASES OF DECIDUOUS FOREST TREES.

INTRODUCTION.

Deciduous forest trees are affected with a large number of different forms of disease, some of which are daily assuming more and more importance. While it has been well known for many years that there are such diseases which are prevalent among broadleaf forest trees, very little has been accomplished up to the present time in the study of their occurrence, the amount of destruction which they cause, and the practical methods of prevention. In dealing with timber tracts, whether they be wood lots or larger areas, it is becoming of increasing importance to take cognizance of those factors which cause depreciation in value of the timber produced, either by decreasing the value of the wood cut or by retarding or preventing the growth of the trees themselves. The various types of disease affect both young and old trees, and from the time the seedling starts to develop until it has reached maturity it is liable to attack by one or more destructive diseases.

In the present bulletin the results of a number of years' investigation of some of the more important diseases of deciduous trees are discussed. No attempt is made to include in this paper all of these diseases. Many are local in their distribution and are as yet of minor importance from a practical standpoint. Many of them affect shade and ornamental trees rather than forest trees. All such are left for subsequent discussion.

For the sake of convenience the diseases of trees may be divided into several groups. Basing the classification on the causes of disease, they may be divided into those caused by unfavorable environmental conditions, including smoke or injurious gases, extreme cold, lightning, excessive water supply, etc., and those caused by living organisms—animals, insects, flowering plants, fungi, and bacteria. Those fungi which cause disease may again be classified into such as grow in the living parts of the tree, including the leaves, the younger branches, the newly formed wood and bark, and the living portion of the root system, and those which grow on the dead or dying parts of the tree, including the heartwood of the trunk, branches, and roots.

ENVIRONMENTAL DISEASES.

In a bulletin of this kind it is impossible to more than refer to certain general types of diseases caused by unfavorable environmental conditions. Of such conditions the principal ones affecting American broadleaf trees are undoubtedly smoke and injurious gases.

SMOKE AND SULPHUR GASES.

In many parts of the United States (7, 37, 71, 109 ^a) extensive areas of deciduous forest lands have been severely injured by the action of smoke or sulphur gases emanating from paper-pulp mills, copper smelters, coke ovens, and blast furnaces. The effects of the sulphur gases first show themselves in deciduous trees either by a discoloration of the young leaves, which ultimately turn mottled yellow and brown and finally die, or by a gradual shriveling and drying of the leaves. A general reduction in the rate of growth likewise takes place, both in the length of the twigs and in the amount of wood formed by the trunk.

In both broadleaf trees and conifers the first effect of smoke or gas injury is usually seen in the tops. This refers especially to trees standing together in a forest or in groups. Single trees may first be affected either in that manner or throughout the crown generally. The leaves in the top gradually become smaller and die, while those near the base may be perfectly healthy. The smaller twigs in the top die next, then larger branches, and with long-continued exposure to injurious gases the tree slowly dies downward until it is killed.

The extent to which trees become diseased as a result of the action of sulphur gases varies materially with the species and the distance from sulphur-gas formation. Buckhout (7) finds twice as much sulphuric acid in the leaves of white oaks grown three-fourths of a mile from a large range of coke ovens as occurred in similar leaves taken from the vicinity of the Pennsylvania State College.

The results of an extended investigation on the effect of smelter fumes on vegetation were recently published by Haywood (37), who confirms the extensive experience of European investigators (36, 112) as to the killing effect on vegetation of very small quantities of sulphur dioxid in the air. Haywood found that in the vicinity of the copper smelters where his investigations were carried on the injury showed itself by the increased sulphur trioxid content of the foliage. He found that the vegetation around the smelter for at least 3½ miles north, 9 miles south, 2½ miles east, and from 5 to 6 miles west had been greatly injured. He suggests that the gases from the

^aThe serial numbers used in this paper refer to the bibliography which will be found on pages 69 to 73.

smelter can be condensed so as to form sulphuric acid, a readily salable product.

Different species of trees show a marked difference in susceptibility to the action of sulphur gases. As a rule, conifers are killed much more readily than deciduous trees. This may be explained by the facts that gases are injurious only to the leaves of trees and that the leaves of coniferous trees are exposed to the gases for several years, while the leaves of broadleaf trees are renewed from year to year. In Germany, where many detailed examinations have been made during a number of years, Haselhoff and Lindau (36) state that the oak is the most resistant tree, followed closely by the different species of maple and ash. The elm, alder, poplar, and linden are more susceptible, and the birch and beech are most susceptible. Haywood states that 3½ miles north of a smelter large numbers of trees, especially pines, were dead.

A series of investigations has been conducted for several years by the senior writer in another region where an extensive mixed forest has been severely injured by sulphur gases emanating from large copper smelters. The forest consists largely of oaks and pines growing on an extremely poor and sterile soil, and the general development of the forest, even before the action of the sulphur gases, was very poor. The different species of forest trees showed a marked difference in susceptibility. The order of susceptibility, beginning with the trees most easily killed, is as follows:

White pine (*Pinus strobus* L.).
 Hemlock (*Tsuga* sp.).
 Scrub pine (*Pinus virginiana* Mill.).
 Pitch pine (*Pinus rigida* Mill.).
 Chestnut oak (*Quercus prinus* L.).
 Hickory (*Hicoria* sp.).
 Black-jack (*Quercus marilandica* Muench.).
 White oak (*Quercus alba* L.).
 Post oak (*Quercus minor* (Marsh.) Sargent.).
 Chestnut (*Castanea dentata* (Marsh.) Borkh.).
 Spanish oak (*Quercus digitata* (Marsh.) Sudworth.).
 Scarlet oak (*Quercus coccinea* Muench.).
 Tulip poplar (*Liriodendron tulipifera* L.).
 Maple (*Acer* sp.).
 Black gum (*Nyssa sylvatica* Marsh.).

This list pertains to trees of pole size. During the sapling stage a somewhat different series can be established. The saplings of post oak and white oak are less easily affected than those of Spanish oak and scarlet oak. The degree of discoloration of the leaves varies, and this should be considered an important factor in diagnosing smoke or gas injury. The following shows the susceptibility to discoloration in a number of different species.

Very easily discolored: Black oak (*Quercus* sp.), hickory (*Hicoria* sp.), scarlet oak (*Quercus coccinea* Muench.), chestnut (*Castanea dentata* (Marsh.) Borkh.), and Spanish oak (*Quercus digitata* (Marsh.) Sudworth).

Partially resistant to discoloration: Tulip poplar (*Liriodendron tulipifera* L.), white oak (*Quercus alba* L.), chestnut oak (*Q. prinus* L.), and post oak (*Q. minor* (Marsh.) Sargent).

Quite resistant to discoloration: Black gum (*Nyssa sylvatica* Marsh.), white pine (*Pinus strobus* L.), maple (*Acer* sp.), pitch pine (*Pinus rigida* Mill.), and hemlock (*Tsuga* sp.).

A great variation in susceptibility to gas injury has been noted by the senior writer in different regions, largely because the general growth conditions have a direct relation to the question of smoke and gas resistance. Trees growing in good soil, not too close together, so that they grow vigorously, are more resistant than those grown on poorer soils or crowded together. Whether smoke or gas has any direct influence on the soil, thereby causing disease in the roots, has not yet been definitely determined. Haselhoff and Lindau (36) conclude that the smoke or gas has no influence whatever on the soil, while Wieler (112) cites a striking instance showing that soil from a smoky district is very injurious to healthy trees planted in it. After three years' growth in soil from a gas district, 100 per cent. of ash, 92 per cent. of maple, 72 per cent. of beech, 8 per cent. of spruce, and no oak trees were dead.

The greatest distance at which the sulphur fumes injured trees was about 3 miles, toward the north and northwest.

The most extreme gas injuries usually occur close to the source of gas production, and injury diminishes rapidly as the distance from this point increases. The injury is furthermore greatest in the direction in which the prevailing winds blow. It is usually most extreme where the source of gas production is in confined valleys or basins (37).

Preventive measures with reference to gas injury can often be carried out with much success. These consist in the construction of tall smokestacks at the manufacturing plant where the injurious gases originate, so as to carry them into the higher strata of the air. The same end may be obtained by the erection of the manufacturing plant at the most elevated point in any given region. A second method which has been used with more or less success in Europe consists in bringing about the condensation of the gases by passing the smoke from furnaces or kilns through water.

UNFAVORABLE SOIL CONDITIONS.

Under unfavorable soil conditions a large number of disease-causing factors are usually grouped, most of which are but imperfectly recognized so far as their specific action is concerned. Among these may be mentioned the absence of a sufficient amount of oxygen in the soil, the absence of necessary food substances, the absence of

water or its presence in excess, the absence of humus or its presence in excess, and a generally unfavorable physical make-up of the soil. For a general discussion of this question see Galloway and Woods (27).

Different species of deciduous trees are affected in different ways by any or all of these conditions. Certain species thrive on dense, clayey soil which has but little aeration and which is generally comparatively free from vegetable matter, while others present a starved appearance on such soil, which is usually recognized in the tree by a dying back of the topmost branches, giving rise to what is usually known as a "stag-headed" condition. This same appearance is brought about in some cases by an excessive amount of ground water. The beech (*Fagus atropunicea* (Marsh.) Sudworth), the tulip poplar (*Liriodendron tulipifera* L.), and the true white oak (*Quercus alba* L.) are trees which are particularly sensitive to excessive water supply in the soil. On the other hand, the red gum (*Liquidambar styraciflua* L.), overcup oak (*Quercus lyrata* Walt.), and water oak (*Q. aquatica* Walt.) are more tolerant in this respect.

Most forest trees demand light and comparatively porous soils with a considerable percentage of humus material, so as to make possible a perfect development of the mycorrhizal fungus and of other species of soil fungi and bacteria. Although we do not fully understand their exact relation to the roots of forest trees, nevertheless these organisms appear to exercise a considerable and usually beneficial influence upon their general development. A reduced rate of growth, pale green, yellowish, or etiolated leaves, and the development of large numbers of short, sucker-like branches may one or all usually be taken to indicate a weakened or diseased condition due to soil troubles. Insufficient room for root development constitutes another very important factor leading to a weakened or diseased condition.

In many hilly or mountainous regions of this country the shallow soil gives rise to a dwarfed and weakened forest growth. No more striking picture of the result of a shallow soil as compared with a deep, rich soil can be found than in the difference evident in the general healthiness of the trees in the Ozark Mountains when compared with those of the western slope of the Appalachian Mountains. Both of these regions receive a heavy annual rainfall, but in the Ozarks the hardpan often comes to within 2 feet of the top of the ground, and as a result a stunted and diseased forest growth develops, while in the Appalachians a very deep soil, rich in humus, permits an extensive and vigorous root development, resulting in healthy, vigorous trees.

EXTREME COLD.

Extreme cold may sometimes result in a diseased condition of trees, either by killing roots or young shoots outright (25, 63, 107, 110, 111), or by causing injuries, such as frost cracks, in the trunks or

branches, which make possible the entrance of disease-producing organisms at a later date. The winter of 1904-5 was characterized by extreme cold and resulted in considerable destruction to forest trees all over the country. Hail, sleet, and snow produce injuries to forest trees which are often extreme; their chief importance lies in the fact that they produce injuries leading to diseases caused by fungi or insects acting upon such trees at a subsequent date.

INJURIES CAUSED BY ANIMALS, WIND, ETC.

The injuries caused by the biting or chewing of animals may be classed in the same category as the injuries referred to under snow and ice, and injuries produced by windstorms may also be placed in the same class. It is very rare to find a large forest tree which is seriously affected because of such injuries, except in the case of violent windstorms. The chief importance of such wounds lies in the fact that they open up pathways for destructive forms of insects or fungi, which are referred to more in detail hereafter. Of these factors, the action of the wind in breaking off branches from more or less mature trees must be considered as the most important.

DISEASES CAUSED BY MISCELLANEOUS PARASITIC AND SAPROPHYTIC ORGANISMS.

The diseases caused by parasitic or saprophytic organisms may for convenience be divided into three groups: Those caused by insects, those caused by parasitic higher plants, and those caused by fungi and bacteria.

DISEASES CAUSED BY INSECTS.

The disturbances in the activities of the living parts of trees caused by insects are not usually classed in any discussion on diseases of plants, although the changes which they produce undoubtedly should be considered rather from the standpoint of the plant than from that of the insect causing them. No special reference will be made in this discussion to any of the diseases of broadleaf trees caused by insects. These have been described in the publications of the Bureau of Entomology of the United States Department of Agriculture by Dr. A. D. Hopkins (42, 43), and a number of them by Dr. E. P. Felt (18 to 21) and others (22, 49, 66, 67, 87) are mentioned in the bibliography.

DISEASES CAUSED BY PARASITIC HIGHER PLANTS.

Many species of deciduous trees are attacked by the common mistletoe (*Phoradendron flavescens* (Pursh) Nutt.). This parasite is very prevalent from the vicinity of the Ohio River southward, and west-

ward to southern California. Throughout southern Ohio, Indiana, Illinois, and Missouri it is found chiefly on the black gum (*Nyssa sylvatica* Marsh.). In the Southern States it is found on almost all species of deciduous forest trees, including the sycamore (*Platanus occidentalis* L.), elm (*Ulmus americana* L.), oaks (*Quercus* sp.), red gum (*Liquidambar styraciflua* L.), ashes (*Frazinus* sp.), cottonwood (*Populus deltoides* Marsh.), and many others of the smaller shrubby species of trees, like the mesquite (*Prosopis juliflora* (Swartz) DC.).

Where it is present in any large quantity, the mistletoe is regarded as a serious enemy of the trees upon which it grows. In the more or

less virgin forest tracts of the Mississippi Valley, extending from southern Missouri into Arkansas and northeastern Louisiana, many tracts are found which are so badly infested as to seriously interfere with the annual rate of wood accretion. In the extreme Southern States vigorous efforts are being made to prevent the attack of the mistletoe, which has become a serious enemy to forest and shade trees in southern Louisiana and Texas. The



FIG. 1.—Oak trees with mistletoe on the branches. Some trees become literally covered with this pest.

parasite is distributed from tree to tree chiefly by birds, and when it has once obtained a foothold in any given region, practically every tree in that locality is affected by it. The parasite is a perennial and gradually absorbs the food materials from the branch upon which it is situated, and not only kills off that part of the branch toward the outside of the tree from its point of attachment, but also causes the formation of large swellings, or tumors, which are most characteristic in the black gum. Figure 1 shows the extent to which the oak may be attacked by this parasite.

There are also a considerable number of smaller mistletoes belonging to the genus *Arceuthobium* which are widely distributed throughout the country. Of these there are two which may be especially mentioned: *Arceuthobium cryptopoda* Engelman and *A. pusillum* Peck. The former is known to occur in various sections of the Rocky Mountains and is injurious to a number of different coniferous hosts; the latter seems to be an eastern form, limited more or less closely to the Appalachian Mountains, and is definitely known



FIG. 2.—A black spruce tree with a large witches' broom caused by dwarf mistletoe.

to occur from the Canadian border to southeastern Pennsylvania. The different species of *Arceuthobium* resemble each other very much in their habits of growth, their manner of seed dispersal, and their effect upon their hosts, so that we may take the best-known form, *Arceuthobium pusillum*, as a type of this group (77).

The seeds are coated with a mucilaginous substance. Upon ripening they are projected for several feet from the seed capsules, and alighting upon an adjacent branch or twig they stick tightly to the bark and there germinate.

They may also be sometimes carried by birds.

The young plant pierces with its holdfast the bark of the twig upon which it is seated and establishes communication with the living portions of the twig. It is thus enabled to feed upon the sap of its host, and in this way a considerable amount of food material is diverted from the outer end of the affected branch to the parasite. About the point of infection a number of branchlets develop, and in the course of a few years there is formed a compact, bushy mass of twigs which

is known as a "witches' broom." (See fig. 2.) During the course of the development of these witches' brooms the sap becomes diverted more and more completely from the outer end of the affected branch to the broom, and finally that part of the branch located beyond the base of the parasite dies. These witches' brooms vary much in size, being from only a few inches in diameter to as much as several feet in diameter and in height. The distribution of the seeds is such that a tree once infected is almost sure to become more affected as time goes on, so that in extreme cases there seems to be little doubt that large trees may be entirely killed by the effects of this plant. The senior writer (77) has referred to the apparent destructive action of this plant. It is evident that the most practical method of eradicating this parasite is by cutting all of the affected trees and burning the infected parts.

It is believed that a number of epiphytic plants sometimes bring about a diseased condition of deciduous trees by smothering the younger leaves and branches. (See fig. 3.) The southern moss (*Tillandsia usneoides* L.) is be-

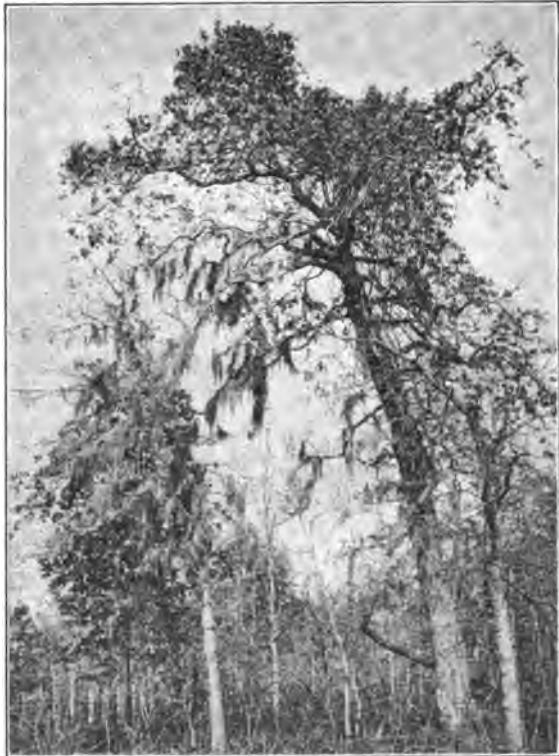


FIG. 3.—Spanish moss on a large oak tree. Note that the branches bearing the moss are dead.

lieved by many to cause the death of leaves and branches of the live oak (*Quercus virginiana* Mill.), red gum (*Liquidambar styraciflua* L.), and other deciduous trees. The dense masses of this plant frequently cover the growing parts of the tree and deprive them of air and light. Another species, *Tillandsia recurvata* L., has recently been reported as killing the live oak (*Quercus virginiana* Mill.) and pecan (*Hicoria pecan* (Marsh.) Britton) in southern Texas. In the Northern States mosses and lichens frequently grow in such profusion that injurious results follow. This is par-

ticularly true of *Usnea barbata* (L.) Fr. and *Ramalina reticulata* (Noehd.) Krempelh. (68). Trelease (100) reports similar effects due to tree mosses. Dense masses of lichens growing on the bark of trees are described as injurious by Waugh (105, 106), Waite (104), and others (44). While these epiphytes may be directly responsible for injuries, and even death, it should be stated that the evidence in favor of such an assumption is not very conclusive. It may be that these plants grow on trees already weakened by other factors. No definite proof has yet been brought forward which would indicate that leaves and branches are killed because of the growth of these plants on the branches.

DISEASES CAUSED BY MISCELLANEOUS FUNGI.

As indicated in the introduction, the fungi which cause disease may be roughly classified into two groups: Those which grow on the living parts of trees and those which grow on the dead parts. Of the forms growing on living parts, one may distinguish in a general way between such as attack growing leaves and those which attack the living branches or wood. Leaf fungi usually attack leaves in spots and produce local disturbances evident as discolored, shriveled spots, which in time dry and break away entirely, leaving holes. In other cases they may bring about malformations of the leaves, causing them to become swollen or much curled and twisted. In many instances the leaves attacked by various species of fungi are killed and prematurely shed. While it is not practicable to include a list of all the forms of fungi which cause leaf diseases of deciduous trees, some of the more important may be mentioned.

MILDEWS.

Among those fungi which attack the surface of the leaf are the various mildews caused by the fungi of the family Erysipheæ. These fungi are found on many species of deciduous forest trees and are most common on the red oak (*Quercus rubra* L.), elm (*Ulmus americana* L.), silver maple (*Acer saccharinum* L.), sycamore (*Platanus occidentalis* L.), and willow (*Salix* sp.). They usually appear during the latter part of the summer, and because of their late appearance do slight harm, except where they attack young forest trees and nursery stock. The small, round, black fruiting bodies are dotted here and there over the diseased surface of the leaf (102).

Finely powdered sulphur dusted lightly over the leaves and young twigs will hold these diseases in check. This is very useful where small trees or nursery stock are to be treated. The standard Bordeaux mixture as well as any other of the efficient fungicides will control this trouble, but sulphur is preferable unless treatment is wished for other fungous troubles also.

TAR-SPOT.

The tar-spot disease of the maple, caused by *Rhytisma acerinum* (P.) Fr. (34, 35, 102), shows as black, irregularly shaped spots on the leaves of different species of maples in the latter part of the summer. These black, blister-like spots sometimes occur very thickly scattered over the leaves, and in cases where the attack is severe the foliage is shed prematurely and the trees weakened thereby. The fungus causing the disease develops beneath the epidermis of the leaf during the summer and forms a black mass of mycelium. After the leaf falls to the ground the fungus continues its development and the following spring produces immense numbers of spores, which it is supposed are blown by the wind on to the newly formed leaves of the second summer.

A number of other species of *Rhytisma* infest other trees than the maples. In some seasons considerable damage is done, especially to nursery stock of various ages, in which case the appearance is very badly marred, both by the premature falling of the leaves and by the black spots upon them while still clinging to the tree. Methods of prevention consist in carefully raking the leaves together and burning them in the fall, thus preventing the fungus from attaining maturity the succeeding spring. This treatment alone if carefully done should prevent serious inroads from this disease.

RUSTS.

Deciduous forest trees are affected only to a limited degree by rust fungi. Now and then one finds a leaf-rust (*Puccinia fraxinata* (Lk.) Arthur) both on the white ash (*Fraxinus americana* L.) and green ash (*F. lanceolata* Borkh.), the telial stage of which occurs on *Spartina cynosuroides* (1). A similar disease is caused on the poplar, willow, and birch by other closely related rusts, namely: *Melampsora populina* (Jacq.) Wint. on poplar (*Populus deltoides* Marsh.) (24), *M. betulina* (Pers.) Wint. on birch, and *M. saliciscaprae* (Pers.) Wint. on willow. These species of rust appear on the leaves in early summer as very minute, bright yellow spots, which gradually turn darker as the season advances, and in the autumn are almost black. The dark-colored spores, which are formed last, are the mature winter spores of the fungus which enable it to live over the winter. The amount of damage done by these rusts is usually insignificant on large trees, but in some seasons when the weather conditions are favorable trees may be entirely defoliated. The most extensive damage done by them is in young plantations, this being especially true of the willow leaf-rust, which has occasioned

considerable damage in osier willow plantations (93). Where the disease is destructive the affected leaves which have fallen to the ground should be raked together and burned.

SYCAMORE LEAF-BLIGHT.

The different species of sycamore, and more especially the common sycamore (*Platanus occidentalis* L.), are very generally affected throughout this country and Europe by a leaf and twig blight caused by the fungus *Gloeosporium nervisequum* Sacc., which in its perfect form is known as *Gnomonia veneta* (Sacc. & Speg.) Kleb. (45). This fungus attacks the young leaves at about the time they reach full growth. The attack usually takes place at or near a large vein of the leaf, resulting in the stoppage of the water supply of considerable areas of the leaf, thus leading to the death of these areas. The deadened portions are usually located, as above indicated, along the main veins of the leaf. Sometimes the attack is made on the petiole of the leaf or on the young twig, causing the death of an entire leaf or bunch of leaves. In severe attacks the leaves are dropped prematurely, and if the attacks are continued with intensity for several years the trees become seriously weakened, and may even die outright.

This trouble is exceedingly common of late years and occurs so universally upon the sycamore that the damage is becoming noticeable, especially upon the park and street trees. Raking together the fallen leaves and burning them, pruning out dead twigs and branches, and spraying with Bordeaux mixture where expense is not a consideration should completely control this trouble (24, 35, 102).

LEAF-SPOTS.

A large number of minute forms of the imperfect fungi belonging to the genera *Cercospora*, *Phyllosticta*, *Ramularia*, and *Septoria* attack the foliage of many of the deciduous trees and cause the so-called "leaf-spots." Leaves affected with these diseases usually exhibit more or less numerous deadened areas of small size. Early in the season these spots are apparently sterile, but later a close examination will reveal a number of tiny black specks located near the middle of the area. These are the fruiting bodies of the fungus, in which are produced the spores for the production of still other colonies. The maple leaf-spot fungus (*Phyllosticta acericola* Cook & Ellis) (24, 102) may be taken as a type of this class of diseases. It is quite common upon the various species of maple, and in severe attacks where a large proportion of the leaf surface is affected the leaves drop prematurely. As a general thing, however, these dis-

eases occur locally and do not affect the leaves so seriously as to cause them to fall before they should naturally. Collecting and burning the fallen leaves and spraying where practicable will control this trouble.

LEAF-BLISTER FUNGI.

The leaf-blister fungi, belonging to the Exoascæ, attack the leaves of a number of the deciduous trees and deform them. The species which is best known in this country is probably *Taphrina caerulescens* (Mont. & Desm.) Tul., which occurs upon the foliage of a number of different species of oak in various parts of the country (114). This disease attacks the newly formed leaves and causes an abnormal growth, so that the leaf looks as if blistered over the affected areas. The development of the fungus is quite rapid, and in extreme cases defoliation may result from its attacks. The cumulative effect of this disease where it occurs for several years upon the same trees may result in the death of the affected trees. Burning the fallen leaves and spraying where practicable will hold this disease in check.

NECTRIA CINNABARINA.

Nectria cinnabarina (Tode) Fr. has sometimes been considered a parasite (23, 27, 52, 69, 102), but should really be considered a hemiparasite. Its spores obtain entrance into branch wounds caused by hail, rodents, or birds, and the resulting mycelium grows through the partially weakened wood and ultimately produces small red clusters of fruiting bodies. The stimulus exerted upon some of the living portions of the cambium layer by the presence of the fungus mycelium frequently accelerates the callus production at the edge of the wood. The callus of the first year is then invaded by the fungous mycelium and killed, and a second layer of callus starts to develop. This may happen for a number of years, until a large area of dead wood having the appearance of a virulent canker is formed on the branch or trunk. Where these cankers grow to be of any size they ultimately result in the death of the branch, or where they occur on a young tree, in the death of the tree itself.

There is a large group of the fungi belonging to the Pyrenomycetes, a number of which attack the living tissues of the bark and the wood of trees weakened by one cause or another. These fungi will usually not attack a vigorous tree, but after a tree has been weakened, either by unfavorable soil or atmospheric conditions or by the attack of some animal, fungus, or insect, they gain a foothold and may produce more or less serious forms of disease. They likewise obtain entrance through wounds into tissues which may properly be called living tissues. The members of the genus *Nummularia* are

good examples of this type of fungus. Their black fruiting bodies are usually found on the dead or dying wood of the branches or trunks of trees, particularly of the oaks and beeches.

CHESTNUT BARK DISEASE.

The chestnut (*Castanea dentata* (Marsh.) Borkh.) has been almost completely exterminated over extensive areas adjacent to the city of New York by a fungus known as *Valsonectria parasitica* (Murrill) Rehm. (54, 55, 56, 60, 61, 62, 70). It causes patches of the bark to die by attacking the cambium and other soft tissues of the bark, and extends in all directions until the branch or trunk is girdled. This leads to the death of those parts above the girdling, and in this way if the main trunk is attacked the entire tree may be killed. The disease attacks the bark on the twigs, branches, and trunk without respect to its thickness. How the fungus gains entrance is uncertain, but inoculation experiments (60, 61) seem to show that it is able to enter only through injuries to the bark. The affected bark has a blackened appearance, is somewhat shrunken, and after a time is apt to be thickly covered with projecting brown or orange or greenish yellow colored bodies, which are about one-sixteenth inch in diameter at the base, often long and twisted or curled, and taper to a slender tip. These are the fruiting bodies of the fungus and are very characteristic of this disease when the weather is moist enough for their formation.

The disease has already spread south to Bedford County, Va., west to Lancaster County and Northumberland County, Pa., and north to Massachusetts. The Japanese chestnut (*Castanea crenata* Sieb. & Zucc.) is in general resistant, although single trees of this species have taken the disease. Immunity tests of all known varieties of chestnuts are now in progress by this Department (55, 56). No adequate preventive measures seem to be known at present, so that this disease is an especially threatening one in the Eastern States.

A similar disease has been noted by the writers upon the Spanish oak (*Quercus digitata* (Marsh.) Sudworth) in the Appalachians, especially in Virginia and western North Carolina. This disease is manifested in the drooping of the leaves and their ultimate drying up, caused by a stoppage of the water supply in the branches by an apparently undescribed species of *Cenangium*.

ROOT-ROTS.

Of the fungi which attack the living roots, two deserve particular notice. Diseases of the root system of broadleaf trees are usually classed together under the term "root-rots." By this is meant a disease which shows in the tree tops by a gradual dying of the branches

and generally by a sudden wilting of the leaves during the latter part of the spring.

Root diseases may be caused by unfavorable soil conditions as well as by fungi, but it has been the experience of the writers that there is a decided difference in the behavior of diseased trees where soil conditions are responsible, as compared with diseased trees affected with some fungous trouble. In the former case the tree dies gradually and the stag-headed condition, together with a gradual decrease in the annual rate of growth, is very pronounced. Where fungi are responsible for root-rot the trees ordinarily show slight indications of the disease in the trunk and crown until it has reached an advanced stage. They then usually send out an unusually large number of leaves and exhibit a strong tendency to overdevelopment of the flowers and fruits.

Two fungi have been found in the United States which have been definitely connected with one or the other type of root-rot. It is probable that there are several others. While it is easy to find a fungous mycelium in diseased roots, it is a comparatively difficult matter to determine with any degree of certainty that the fruiting bodies found near diseased trees bear any direct relation to the mycelium which occurs in the diseased root system.

Only brief reference can be made here to the manner of growth and attack of the two root-rotting fungi. The more important of these is the ordinary "Hallimasch" of the Germans, or the so-called honey mushroom (*Armillaria mellea* (Vahl.) Quelet) (27, 32, 34, 35, 102), a form of which may be what has been named *Clitocybe parasitica* by Wilcox (113). The fruiting bodies of this fungus usually occur in large numbers around the base of the trunk of a diseased tree. They are also found frequently in dense masses on and around dead tree stumps. The fruiting bodies are honey colored and the tops have a more or less viscid appearance, speckled with white. The stems are somewhat swollen at the base, and a short distance below the pileus they have a distinct ring, or annulus. The gills are white, and from them large quantities of white spores are shed, which frequently cover the ground around the fruiting bodies, like a mealy white powder.

The most characteristic parts of the honey mushroom are the so-called rhizomorphs, known popularly as "shoe strings." These consist of hard, black strands which occur singly or in large numbers, frequently much interlaced and branched, extending in all directions through the ground and along the roots or stumps of affected trees. Where they grow under the bark and in the cambium layer, they become much flattened. The fruiting bodies of the honey mushroom are found to develop at the ends of these rhizomorph strands.

The fungus usually gains entrance through some wound in the root system, although it has been maintained that it can penetrate the bark of uninjured trees. The young mycelium grows into the cambium layer, attacks the living cells, and finally completely encircles the base of the trunk of an affected tree. As the fungus continues to develop, masses of the mycelium form rhizomorph strands. The ultimate effect of the presence of the fungus is to kill the living layers of the tree near the ground line, causing a drying of the top and the ultimate death of the entire tree.

The fungus continues to live in the dead root system and in the base of the trunk of the tree for a number of years, and the rhizomorphs are able to continue their growth from root to root for some years after the trees have died. It is this faculty which makes this fungus an exceptionally dangerous one, because it is thereby enabled to spread from tree to tree through the soil with great readiness. The writers' observations show that the dead pieces of roots left in newly cleared forest land are sources of infection for the roots of fruit trees when planted on such land a few years later.

The second fungus, which affects trees very much as does the honey mushroom, is a root fungus (*Thelephora galactina* Fr.) (82) which has so far been found only on various species of oak, particularly the black oak. It has been found to occur commonly in various parts of the Ozark Mountains in southwestern Missouri, western Arkansas, and eastern Indian Territory. The long white strands of this fungus penetrate the bark of oak trees until they reach the living tissues. The fungus generally attacks the younger trees, and when the soil conditions are favorable for its development, considerable areas of oak forest may be killed as a result of its activity. It is one of those forms which cross from oaks to fruit trees when planted on newly cleared land.

SLIME-FLUX DISEASES.

A class of diseases known as slime-flux diseases should be referred to here, because they are frequently found on many of the deciduous trees. The slime-flux diseases are common in this country on the yellow birch (*Betula lutea* Michx. f.), elm (*Ulmus americana* L.), dogwood (*Cornus florida* L.), apple (*Pyrus malus* L.), and maples (*Acer* spp.). They are characterized by the appearance of various colored, slimy masses with a decidedly acid odor, which start at or near wounds caused by different agencies (23, 102). They make their appearance usually early in the spring when the sap, containing more or less sugar, flows from the wounds mentioned. In this sap a number of forms of algæ, bacteria, and fungi, usually associated with certain low animal forms, flourish extensively. The fermentive processes set up by one or all of these forms kill the underlying bark and cam-

bium, and where they are allowed to develop to any extent their destructive action may extend completely around a tree, resulting in the death of branches, and sometimes of the entire trunk. The slime-flux diseases can hardly be considered of great practical importance and only become so where valuable shade or park trees are affected. As a preventive measure, the precautions to be taken for wounds, referred to farther on, are applicable.

✓ DISEASES CAUSED BY WOUND FUNGI.

WHITE HEART-ROT CAUSED BY FOMES IGNIARIUS.

The principal diseases of deciduous forest trees are caused by a group of fungi which grow in the heartwood of the trees. The chief interest which attaches to the maintenance of wood lots or forest tracts comes from the fact that such tracts are maintained for the wood which they produce. Anything, therefore, which either reduces the rate of wood production or actually destroys the wood formed is of particular interest.

The fungi which are responsible for the decay and destruction of the heartwood of various broadleaf trees are quite numerous. They are more or less alike, however, as to their manner of entrance into the tree, their subsequent development, the production of their fruiting bodies, and the manner of prevention. In the following, one of the commonest of these fungi, the so-called "false-tinder fungus" (*Fomes igniarius* (L.) Gillet), is taken as a type, and such specific differences as apply to the other forms are given in the special chapters in the latter part of this bulletin which are devoted to the more important of these wood-rotting fungi.

NATURE OF DISEASE CAUSED BY FOMES IGNIARIUS.

The disease of deciduous trees caused by the false-tinder fungus (*Fomes igniarius*) may be called the "white heart-rot." It is usually confined to the heartwood of the tree, including the trunk and larger branches, but it may also affect the sapwood. As a result of the action of the false-tinder fungus the heartwood is changed into a whitish, soft substance, which differs little in the different species of hosts.

A tree attacked by the fungus shows no particular change in its general external appearance during the early stages of the disease; in fact, it is practically impossible to recognize a diseased tree until the fruiting bodies of the fungus form on the outside of the trunk. During the later stages of the disease affected trees can be recognized by the presence of the fruiting bodies of the fungus, of which there may be from one to a dozen on a single tree, at or near wounds, branch

stubs, or knot holes. When these fruiting bodies appear it may be taken for granted that the disease has progressed within the trunk in both directions for 2 or 3 feet from the point of infection.

The disease may affect trees at any time. In its final stages it brings about a complete destruction of the heartwood of the tree, so that it becomes weakened and liable to be broken off by windstorms, thus terminating the existence of the affected tree. Diseased trees may sometimes be recognized by the sound emitted when the trunk is pounded on the outside. While healthy trees give a vibrant sound, trees in the later stages of the disease give a more or less deadened sound. This is especially true where, owing to the destruction of the decayed wood by insects, holes have been formed. As a general rule, however, the only safe way to recognize a diseased tree is by the presence of the punks or fruiting bodies on the outside of the trunk.

When cut in two, the trunk of a tree affected with the white heart-rot presents an appearance as shown in Plate II and in Plate III, figure 1, representing both the early and the later stages of the disease. It will be noted that the center of the tree has been transformed into a pulpy mass having an irregular outline. This mass is definitely limited on the outside by one or more narrow black layers. In some instances the wood is discolored outside of these black layers. This is more marked in the poplar than in any of the other hosts of the fungus. One of the most characteristic features of the decay of the trunk is that the decayed wood is confined to one large central mass, differing in this respect from the pocket-like destruction brought about by several other wood-destroying fungi, notably *Stereum frustulosum*, which is mentioned later in this paper.

Trees attacked by the false-tinder fungus rarely become hollow, for after the wood has become thoroughly decayed by the fungus it remains in the interior as a pulpy mass. Where hollows do occur, they are caused by various insects which bore through the decayed wood.

SUSCEPTIBILITY OF DIFFERENT HOSTS TO THE WHITE HEART-ROT.

The false-tinder fungus is probably one of the most widely distributed forms of wood-destroying fungi; it occurs on more different species of broadleaf trees than any other similar fungus. Among its hosts are to be found the most important timber trees of the deciduous forests of North America. So far as known to date, the fungus has been found on the following host species: Beech (*Fagus atropurpurea* (Marsh.) Sudworth), aspen (*Populus tremuloides* Michx.), balm of Gilead (*P. balsamifera* L.), willow (*Salix* sp.), sugar maple (*Acer saccharum* Marsh.), red maple (*A. rubrum* L.), silver maple (*A. varinum* L.), striped maple (*A. pennsylvanicum* L.), yellow birch

(*Betula lutea* Michx. f.), butternut (*Juglans cinerea* L.), black walnut (*Juglans nigra* L.), oaks (*Quercus* spp.), apple (*Pyrus malus* L.), and hickory (*Hicoria* sp.). In Europe it is everywhere prevalent upon the broadleaf trees, but occurs more commonly on the beech (*Fagus sylvatica* L.), oaks (*Quercus* spp.), and alder (*Alnus incana* Medic.).

In this country certain species are almost universally affected with the white heart-rot, irrespective of the region where they are found. An excellent instance is the aspen. This tree, which (72, 99) has the widest range of any species of forest tree in North America, is subject to this disease very generally. *Fomes igniarius* has been found on this host from such extreme points as Maine, western Canada (51), Oregon, Colorado, and southern New Mexico.

In New York and New England the beech has been found to be the most common host of this fungus. Wherever any considerable amount of beech timber is found, white heart-rot is prevalent. In some sections as many as 90 to 95 per cent of the beech trees of merchantable size have been found affected with this disease. Both the butternut and the black walnut are frequently affected. The oaks are quite generally affected, but more especially those belonging to the black oak group.

A marked difference in susceptibility is occasionally found in certain species of the same genus. Thus it has been reported that the aspen is more seriously affected in western Canada than is the balm of Gilead (51). Among the maples it has been found that the striped maple is quite generally attacked in those localities where the disease is present in the same vicinity upon others of its host species. The silver maple seems to be nearly as susceptible as the striped maple, while the red maple and sugar maple are rather rarely affected. The yellow birch is even less frequently attacked than are the red or sugar maples.

DISTRIBUTION OF *FOMES IGNIARIUS*.

The false-tinder fungus (*Fomes igniarius*) is known to occur throughout the United States. In general, its distribution may be given as follows: In North America it occurs in Alaska, in various parts of Canada, throughout the United States, and in the Bahamas. In South America it has been collected in Surinam, Brazil, Argentina, and Patagonia. It is prevalent throughout Europe from England to Russia, and from Scandinavia and Finland to Italy and Spain. In Asia it is known from Siberia, Japan, the Philippines, and India. It also occurs in Tasmania, Australia, Java, New Zealand, Admiralty Islands, Sierra Leone, and South Africa.

It will be noted that these localities embrace the four quarters of the world. Because of the lack of knowledge of the mycological flora of many countries, no statement can be made as to the occur-

rence of this fungus in them. The recent statement of Schuman and Lauterbach (92) that it occurs the world over can scarcely be doubted.

The amount of destruction caused by this fungus in the North American forests is beyond computation, because of both the wide occurrence of the fungus and the large number of host species upon which it grows. The loss caused thereby differs considerably with the locality and the host species. The greatest losses are brought about in more or less definitely limited localities. There are districts which are very badly affected with this disease, and others which are comparatively free therefrom, which may be considered a good augury from the standpoint of prevention.

Where this fungus occurs extensively almost the entire stand of certain species is frequently found so badly injured with the white heart-rot as to be practically worthless. In a certain area of deciduous forests in the Adirondacks in the State of New York, where the timber was comparatively a mature stand, actual counts showed that from 90 to 95 per cent of the otherwise merchantable trees of beech were rendered valueless from the attacks of this fungus. The same is true to a certain degree in the regions where the aspen is grown extensively for pulp wood. In the New England States, Colorado, and New Mexico it is almost impossible to find healthy groves of aspen which have attained any age, because of the extreme destruction brought about by the false-tinder fungus. In the mature beech stands of Texas and Louisiana, where the trees are 150 years old or more, a very large percentage are wholly decayed in the interior by this fungus. (Pl. II, fig. 1.) The same is true of many of the tracts of the Appalachian deciduous forests. It may be stated that the amount of damage caused by the white heart-rot is very great; and its wide distribution, together with the almost universal susceptibility of deciduous trees thereto, make it the worst enemy of these species, especially during the period when they are approaching maturity.

DESCRIPTION OF THE FUNGUS.

The fungus *Fomes igniarius* has been known for a great many years and has been made the subject of a large number of descriptions, as a result of which a very extensive bibliography has developed, which is too bulky to be here included. It is probably one of the oldest fungi known, as it attracted attention in the early days because of its size and uses. Lightfoot (47) in 1777 made the following statement:

An excellent touchwood is made from this fungus, by first paring off the outer rind, then boiling the remainder in lye, and afterwards drying and pounding with a hammer, or else pounding and boiling it up with saltpeter. The same fungus beaten into soft square pieces is well known to surgeons by the name of *Agaric*, and has been much celebrated for stopping the bleeding of arteries; it has not, however, proved altogether

successful unless in the smaller vessels. We are informed by Gleditsch that in Franconia he has seen these beaten pieces of *Boletus* which resembled the softest leather curiously sewed together and made into garments.

The false-tinder fungus has been well known in Europe for about two hundred years. Its synonymy is given below:

- Boletus igniarius*, Linnæus, C., *Species Plantarum*, p. 1176. 1753.
Polyporus igniarius, Fries, E., *Syst. Mycol.*, vol. 1, p. 375. 1821.
Fomes igniarius, Gillet, C. C., *Champ. France*, vol. 1, p. 687, pl. 156. 1878.
Phellinus igniarius, Quelet, L., *Enchir. Fung.*, p. 172. 1886.
Mucronoporus igniarius, Ellis, J. B., and Everhart, B. M., *Jour. Mycol.*, vol. 5, p. 91. 1889.
Pyropolyporus igniarius, Murrill, W. A., *Jour. Mycol.*, vol. 9, p. 101. 1903.

The name *Fomes igniarius* has been accepted and is in general use, while the three later generic names are not so well known or so generally accepted. It seems best to use the more common and better known name in the present account of this fungus.

The false-tinder fungus (*Fomes igniarius*) is one of the most conspicuous of the so-called punks, or shelf fungi, which grow upon living trees. It varies much in shape, size, and color, depending upon its age and upon the species of tree upon which it grows. It is commonly more or less hoof shaped, measuring about as much in thickness as in width. Its size varies from 1 or 2 inches to 12 inches or more in width. The upper surface is smooth in the younger forms and becomes concentrically marked as the fungus grows older. It is characterized by a very hard external layer, which is at first brown, gradually becoming black, and in the older forms is considerably roughened and cracked. The cracks, however, rarely penetrate far into the mass of the sporophore. The sporophores are very woody and of a rusty brown color on the inside. The pores are formed in layers, one below the other, and the sporophores apparently may grow to a great age. The writers have found them with 50 layers. Atkinson (4) reports one with 80 layers. The average number is from 15 to 30 layers, presumably indicating an age of approximately the same number of years. The lower surface is gray to red-brown in color, varying according to the season. The edge is yellowish brown when first formed, and very much lighter in color than the top. Toward the end of the season the newly formed portion weathers considerably above and has a rusty appearance. Although there is considerable variation in the form of the sporophore, its general characteristics are so decided that it is rarely confounded with any of the other wound fungi.

SPREAD OF THE DISEASE.

The white heart-rot, as has been stated, is caused by the growth and development in the wood of the trees of the mycelium of *Fomes*

igniarius. The fungus gains entrance into the trunk of the tree through some wound; in other words, it is a wound parasite of the most distinct type. An examination of thousands of infected trees has shown without exception that there must be some wound before infection will take place. A careful series of observations has furthermore shown that the point of entrance is usually indicated some years later by the location of the oldest sporophores. These sporophores are usually situated on old branch stubs or in holes left when the base of the branch rotted away.

In a large percentage of cases infection takes place through old branch stubs. The spores of the false-tinder fungus germinate on a stub, and the hyphæ grow down through the wood of the stub until they reach the heartwood of the main trunk; from this point they grow both up and down in the heartwood, usually starting near the pith, and advance concentrically outward. The destruction of the wood follows very shortly after the entrance of the mycelium into the trunk, progressing both outward and up and down as long as the tree lives. The time which elapses between the injuring of a tree and infection necessarily varies, depending chiefly upon the presence of spores and climatic conditions.

The formation of sporophores takes place usually at the point where infection originally occurred. This can readily be proved by an examination of the diseased area within the trunk, especially during the early stages of the disease. The formation of sporophores subsequent to that of the first one is determined by the location of the tree, the climatic conditions, the size and vigor of the tree attacked, and the number of side branches which may permit the growth of the mycelium from the center to the outside, thereby making possible the formation of additional sporophores. The number of sporophores which will form on a tree is largely determined by the latter fact. Thus, in the aspen, in which wounds made by the dying of the lower branches are healed over with difficulty, the number of sporophores is very much larger on an individual tree than is the case with trees which heal over such wounds more rapidly, like the beech and the sugar maple. It is not uncommon to find a diseased poplar tree with anywhere from three to twelve sporophores on various parts of an affected trunk (Pl. I); in the beech and birch a smaller number is the rule.

The growth of the mycelium of the fungus is usually confined to the heartwood of the trees. Hartig states that the fungus may enter trees by means of slight wounds in the sapwood, and describes the manner in which the fungus starts its development in the sapwood, growing from the sapwood into the heart. His observations refer to the oak, however, with which comparatively little work has been done in this country.

After the fungus has once obtained a start in the wood of the trunk it may encroach upon the sapwood, and after a time reach the newer sapwood immediately under the bark, thereby causing the death of that portion of the tree, and, when the entire diameter of the trunk is affected, of the whole tree itself. This is especially true of the aspen and the striped maple. As this fungus occurs so generally upon living trees, it has been thought that it would cease growing after the host tree had died. From a large number of observations made by the junior writer it has been found that this is not really the case, for many trees have been found entirely dead and leafless upon which the fungus was still growing vigorously. This is true not only with one or two of the host species, but, so far as could be determined, with all of them. In some cases a vigorously growing new layer was found on the underside of sporophores growing on trees and stubs which certainly must have been dead for a year or more. Standing stumps were also found bearing living sporophores several years after the death of the diseased tree. This finding that the sporophores will continue to develop on dead wood is believed to be of considerable importance, because the dead wood coming from a tree diseased by this fungus in which the mycelium is present must be considered a possible source for further infection of healthy trees.

INFLUENCE OF ENVIRONMENT ON PREVALENCE OF WHITE HEART-ROT.

The possible factors which may influence the distribution and growth of *Fomes igniarius* are many and varied in character. Among them the following deserve consideration: Climate, surrounding forests, character of the soil, species of host, age of host, rapidity of growth of host, rate of healing of branch wounds, and presence of wounds on host.

The climate has very little to do with the distribution and virulence of this disease. It occurs in the humid forests of the eastern United States as well as in the very dry regions of New Mexico and Colorado; and it seems to flourish as well in semitropical and tropical countries as in the colder regions of the north.

The character of the surrounding forest seems to have absolutely no influence upon the frequency of the disease, except as it does or does not contain some of the host species in abundance. The fungus seems to occur with equal frequency in pure stands and in mixed forests. In other words, the aspen is found diseased just as frequently in a mixed stand with other trees as in a pure stand of aspen.

The character of the soil has little or nothing to do with the occurrence of *Fomes igniarius*. The species of the host, on the other hand, has a very considerable influence on the frequency of the occurrence

of the disease. As stated before, the aspen, the beech, and the butternut, in the order given, seem to be the most frequently diseased of all the hosts upon which the fungus has been found.

The age of the host tree is probably the most important factor connected with the distribution of the disease. It has been indicated that the principal mode of entrance of the fungus is through dead branches. Trees which are not old enough to have many dead branches or which are not old enough to shed their lower branches



FIG. 4.—An aspen tree with many dead lateral branches; each of these offers a good entrance for wound fungi.

are free from the disease. When a branch dies and is broken off its wood is left exposed to the attacks of the fungus.

Where trees are very much suppressed the fungus may be found on trees only 1 or 2 inches in diameter; but it will be found on examination that such suppressed trees are in reality of a considerable age. In general it may be said that none of the common deciduous forest trees are affected with the white heart-rot before they are 20 years of age, and most of them will

not become affected until they are considerably more than 20 years old. The aspen and the butternut become infected after they are 20 to 25 years of age. This is especially true of the aspen, on which dead branches remain on the lower part of the trunk for years after they are dead (fig. 4). A clean-stemmed forest of beech standards will show far less susceptibility when 50 or 60 years old than a similar stand in which the dead branches stick out in large numbers from the lower portions of the trunk.

The chances for the healing of branch wounds are generally very much better for a tree with thick sapwood than for one with thin sapwood. From an examination of trees affected with the white heart-rot the following average ages have been determined as indicating the periods beyond which infection is liable to result: Butternut, about 15 to 20 years; black walnut, about 20 years; aspen, 20 to 25 years; yellow birch, 20 to 25 years; beech, 25 to 35 years; silver maple, about 35 years.

The rate of growth of the host tree affects chances for infection only so far as it influences the rate with which such trees are able to heal wounds. Vigorously growing trees of a certain species will as a rule show less tendency toward infection than slow-growing trees of the same species. Anything which tends toward the healing of the wounds formed in a tree as it grows older will reduce its chances of becoming diseased.

The formation on trees of wounds other than those caused by the natural dying and breaking away of branches on the lower part of the trunk has a material influence on the chances for infection. Short-lived trees, like the aspen, in which with increasing age there is a rapidly increasing tendency for all branches to be broken off by windstorms, show a greater tendency toward diseased conditions as the trees reach maturity and afterwards than is the case with trees such as the beech and oak, which are long lived, where the tendency toward the breaking of the branches, due to ice storms and windstorms, is smaller.

Summing up the factors which control the entrance of the false-tinder fungus, one finds that the chief factors, given in the order of their importance, are: First, presence of wounds on the tree, this involving the natural rate of healing of lateral branches, especially on the lower parts of the trunk; second, age of the tree; and third, greater or less tendency on the part of trees to maintain a close crown, reducing the chances for the breaking off of large branches by windstorms and ice storms.

ULTIMATE FATE OF DISEASED TREES.

A tree affected with the white heart-rot may continue to live for many years, even if badly diseased. This is particularly true of long-lived trees, like the white oak and the beech, and especially if the amount of wood destroyed in the trunk is so small as to reduce the strength of the trunk but slightly. Where the disease encroaches upon the sapwood, as in the case of the aspen, trees may be killed by the disease; and this actually does take place in many instances. The chief destructive results, however, should be considered from the point of view of the wood destroyed by this fungus.

Trees are chiefly grown for the wood which they may produce, and, with the possible exception of shade trees, anything which destroys the heartwood of the tree causes serious loss. These losses increase with the age of the tree, for the older the tree becomes the more wood is destroyed. Ultimately all affected trees are blown over, it being only a question of time before this happens. *Fomes igniarius*, in fact, may be considered one of the chief factors determining the length of life of many of the deciduous forest trees.

EFFECT OF THE FUNGUS ON THE WOOD STRUCTURE.

The diseased wood is very sharply bounded from the healthy wood by black layers about one-eighth to one-sixteenth of an inch in width. (Pl. II.) There may be but a single one or there may be several arranged more or less concentrically. (Pl. II, fig. 2.) Just outside of these layers there is a layer consisting of from three to six annual rings, which is darker in color than the normal wood because of the infiltration into the same of products of the decomposed wood. When there is but a single black layer the rotted wood extends out to this; when there are several such layers the completely rotted wood may extend out only to the inner layer, while between the series of layers the wood will be found in various stages of partial decomposition. These black layers never exactly follow the annual rings of growth. They are usually very irregular, crossing the rings back and forth. The completely rotted wood is white to light yellowish in color, according to the species of tree in which the fungus is growing. When rubbed between the fingers it breaks up into fine flakes, but does not powder. It has lost its strength and can no longer be called wood.

In the completely decayed wood the mycelium of the fungus is abundant in the large vessels and medullary rays. The walls of the wood cells are very much thinner than in the normal cells, and in many places the middle lamellæ are wholly lacking. The addition of chloridid of zinc shows that the walls which are thinnest are composed of cellulose. In other words, one of the principal effects of the fungus is the solution of the lignin elements of the cell wall. Extending from the large vessels the fungous hyphæ pass freely across the wood cells and between the remnants of the walls, binding them together in a more or less compact mass. In the earlier stages of the disease the hyphæ develop most abundantly in the medullary rays, and from these they pass to the wood cells through the pits. As a rule the hyphæ do not enter the cells at other points by a direct solution of the walls.

Shortly after a hypha has passed through a pit the latter enlarges, forming an irregular hole in the walls, and as the solution of the walls continues two or more such holes coalesce, forming a large opening. At this stage the affected cell walls still retain enough of their lignin

elements to give the lignin reactions. The solution of the middle lamella generally begins near the enlarged pit openings and continues rapidly until the individual fibers fall apart. In the earlier stages of the disease a yellowish substance which is readily soluble in alkalis is present in many of the cells. It is this yellow color which frequently passes outward in advance of the actual destruction of the wood and gives it a darker coloration. In the earlier stages of decay the young mycelium is colorless, but when exposed to the air turns brown.

PREVENTIVE MEASURES.

Since *Fomes igniarius* is a wound parasite, but two methods of prevention can be suggested: One of these consists in the prevention of wounds and the other in the removal of the primary sources of infection. On large forest tracts it is at present impossible to deal with individual trees for the purpose of treating wounds. Much can, however, be done in a general way to reduce the chances of natural wound infection. Attention has already been called to the fact that the tendency toward natural pruning in several species of deciduous forest trees, with a consequent rapid healing of the wounds caused by the breaking away of branches, very materially reduces the chances for infection during the early life history of the tree, the period during which the greatest wood development takes place. The growing of straight, clean-stemmed trees results in a healthier stand, in which the chances for infection are very much less than in a similar stand of the same age where the lower branches are left dead on the trees for many years. It is often practicable to assist the natural pruning tendencies of trees, and where this is possible the results will be correspondingly great.

The most practical method for combating the heart-rot of deciduous forest trees at the present time is undoubtedly the removal of the possible sources of infection. This is especially true of more or less circumscribed areas. Wherever the management of forest tracts is undertaken, one of the first things which should be done is to make a careful search for trees already infected and to promptly remove them.

Where an infected tree is found it should always be cut down. Removing the sporophores from such trees and leaving the trees standing is inadvisable, because when a fruiting body is removed it will soon be renewed, thus necessitating going over the same tract many times, with lessened chances for success. The removal of a diseased tree is furthermore made advisable by the fact that when the sporophores once appear upon such a tree it is a sure sign that the heartwood of that tree is rapidly being destroyed. Where diseased trees are cut in the early stages of infection, as evidenced by

the appearance of but one or two sporophores, it may often be possible to save a considerable amount of wood and lumber. If only the sporophores are removed and the trees left standing, the fungus continues growing in the tree, and every year that such a tree is left in the forest it depreciates in value, and ultimately becomes entirely worthless. The removal of diseased trees should be undertaken no matter to what species they may belong. So far as we now know, *Fomes igniarius* when growing on one host species may infect the others, and in a deciduous forest a diseased maple must be considered a source of danger for the other host species until it is shown that the maple fungus is a distinct form which can not infect other species. In the absence of such proof it is advisable to cut down the diseased maple and make the protection of the remaining trees certain.

Any examination of a forest tract for diseased trees should be made thoroughly, so that all diseased trees may be removed, for the existence of a single tree bearing a number of actively growing sporophores is sufficient to cause the infection of a large area, since the spores of the false-tinder fungus are very light and are blown to great distances by the wind. All diseased wood should be burned, as sporophores continue to develop on diseased wood even after being cut from the tree.

Where trees are sufficiently valuable to warrant their being treated individually, careful wound protection is advisable. Wherever a branch of any size breaks off or where deep wounds are produced in the trunks of trees, such wounds should be carefully trimmed so that the surfaces are smooth. The wounds should then be coated with some good antiseptic substance which can be rapidly applied and which will have sufficient penetrating power to infiltrate for a distance into the wood fiber. The best material for this purpose is coal-tar creosote. This should be heated until thoroughly liquid, when it can be applied with a paint brush. It not only has the distinct advantage of killing all fungous spores which may be present or which may subsequently lodge in the wound, but it is also a good preventive against boring insects.

The painting of wounds is especially advisable where such wounds are large. One instance which occurs to the writers where such wound treatment would have proved very advantageous if it had been carried out in time was in a large tract of chestnut forest. The large trees had been cut out a number of years before the writers' observations were made, and shoots had started from the bases of the old stumps. These shoots were sufficiently old to have formed heartwood. A large percentage of these young trees were found affected at the base of their trunks, the fungus having entered

from the old stump into the heartwood of the living trees. If the stumps had been painted with creosote soon after the trees were cut, this could not have happened.

A similar instance was noted some years ago in a catalpa plantation in eastern Kansas, where the trees had been cut off while they were still young in order to stimulate the production of a single large shoot. The high percentage of diseased trees in this plantation is directly ascribed to the fact that the fungus had entered the new shoots from the old stumps. It would have been easy and comparatively inexpensive to have coated the cut surfaces of the stumps with coal-tar creosote at the time the trees were cut. Where this can be done, especially where coppice growth is expected, as in the case of the chestnut, such wound treatment may be found practicable and will at all times be advisable.

✓ RED HEART-ROT CAUSED BY *POLYPORUS SULPHUREUS*.

The sulphur polyporus (*Polyporus sulphureus* (Bull.) Fr.) is found on a large number of deciduous forest trees, but chiefly on oaks (*Quercus* spp.), chestnut (*Castanea dentata* (Marsh.) Borkh.), maples (*Acer* spp.), black walnut (*Juglans nigra* L.), butternut (*Juglans cinerea* L.), alder (*Alnus* sp.), locust (*Robinia pseudacacia* L.), apple (*Pyrus malus* L.), pear (*Pyrus communis* L.), etc. It is widely distributed throughout the United States and Canada and in most of the forest regions of Europe, where it is regarded as a destructive parasite, both on deciduous trees and conifers (32). Reference to the disease caused by this fungus was first made in this country by Galloway and Woods (27), and later by von Schrenk (78).

The fruiting bodies of the sulphur polyporus are among the most conspicuous of the larger fungi found in the forests. They form a series of shelves, from 2 to 20 or more, overlapping one another. Sometimes they form very close together, so as to produce a large, round mass about the size of a person's head. (Pl. IV, fig. 1.) The upper surfaces at first are a bright orange-red, with a brighter red at the rims. As they grow older they assume a distinct sulphur-yellow color, which is also the color of the under surface. When young, the upper surface is very moist, somewhat hard, and when bruised turns brown. The whole fungus is soft and fleshy when young, and when squeezed a clear yellowish liquid exudes. As the plant grows older it becomes much harder, and shortly after maturity becomes quite firm and brittle. The fruiting bodies of this fungus very rarely remain on the tree for any length of time, because they are attacked soon after reaching maturity by a number of insects, which speedily destroy them. The fungus is also eagerly sought by mushroom hunters on account of its excellent and well-known edible qualities.

The fruiting bodies of *Polyporus sulphureus* usually occur in some large knot hole on the side of the tree trunk; they are, however, frequently found on stumps and fallen branches. The mycelium of the fungus is capable of living in the dead wood of a tree for many years, and when the proper conditions recur the fruiting bodies continue to form each year, or with a marked periodicity in alternate years. A large branch was broken from a chestnut tree which had been diseased by the sulphur polyporus for many years, and accurate observations were made upon this branch for five years. It was found that in July or August large masses of the fruiting bodies developed from this branch. The fruiting bodies of the sulphur polyporus form on trees and stumps during the middle or latter part of the summer and, as stated, can be found for only a short time.

The destruction which *Polyporus sulphureus* brings about in the heartwood of trees is very similar for all of the host trees upon which it grows, irrespective of whether they are coniferous or deciduous species. The decayed wood resembles a mass of red-brown charcoal. There are various degrees of coloration, depending upon the host, being darker in most of the species of oak and lighter in chestnut and walnut. The decayed wood is characterized by a series of concentric and radial cracks extending irregularly through it. (Pl. IV, fig. 2.) These cracks develop as the wood is destroyed, and are caused by the decrease in volume of the affected wood. The fungus forms thin, leathery sheets in the cracks. In wood which is badly decayed a blow with a hammer will cause the decayed wood to drop out in the form of fine powder, leaving the thin sheets, consisting of densely interwoven threads of the fungus, as a skeleton framework. The decay of the wood itself is a very uniform one; in other words, there is no localized decay, but the wood is uniformly converted into a brown, brittle substance which readily crumbles into a fine powder when rubbed between the fingers. The red-brown coloration, the presence of large white sheets extending throughout the mass of the decayed wood, and the presence of numerous large and small cracks extending radially, tangentially, and transversely through the mass of decayed wood readily enable one to recognize wood destroyed by the sulphur polyporus. In the oaks the broad medullary rays persist longest.

The age at which trees are attacked by this fungus varies considerably with the region in which they are growing and the conditions under which they are situated. Healthy, rapidly growing trees which heal their wounds quickly remain free from the disease much longer than stunted, poorly grown trees. The youngest trees in which the red heart-rot was found were about 50 years old.

Preventive measures consist of essentially the same treatment as is suggested for *Fomes ignarius*. In view of the fact that the myce-

lium of the sulphur polyporus usually enters the trees in the crown, it is hardly practicable to attempt wound treatment. The chief endeavor, therefore, must be concentrated on the removal of the diseased trees. Any tree which shows signs of development of sporophores of *Polyporus sulphureus* should be cut down at once, and all of the wood affected with the mycelium of this fungus should be burned.

PIPED-ROT OF OAK AND CHESTNUT.

The disease which we distinguish under the name "piped-rot" especially affects oak trees, particularly those of the black oak group. (Pl. V, fig. 1.) It has also been found in the beech (*Fagus atropurpurea* (Marsh.) Sudworth) and yellow birch (*Betula lutea* Michx. f.). This disease has been found widely distributed throughout the deciduous forests of the Mississippi Valley.

A similar disease, which is probably caused by the same fungus, occurs in the chestnut (*Castanea dentata* (Marsh.) Borkh.). (Pl. V, fig. 2.) The heartwood of affected trees has a mottled appearance, showing irregular, small, pocket-like patches of white fibers, separated by wood fibers still retaining almost the normal color of the heartwood. The white areas first appear in the wood in the form of small lens-shaped areas, which gradually increase in size longitudinally, and after a while become confluent, so that in the course of time the wood frequently shows a series of irregular white lines extending longitudinally. As the disease progresses the white areas change into small pockets, or holes, lined with fibers. Where these holes reach any size, they frequently become filled with a dark, red-brown mycelium. In its last stages the diseased wood is composed of loose masses of white fibers mixed with the brown mycelium and inclosed by thin unaffected layers of wood. The preliminary stages of the disease are characterized by a darker coloration of the heartwood, which starts near the center of the trunk, gradually spreading outward until it reaches the sapwood. In Plate V, figure 1, this darker coloration shows on the boundary between the partially decayed wood and the sapwood.

It will be noted that the disease is confined strictly to the heartwood of the tree. The changes just described originate near some branch stub, very much as has been described for *Fomes igniarius*. Without referring in detail to the microscopical changes which take place in the wood, it may be said that the white areas are due to a lining of cellulose fibers, which stand out more or less separately from one another, on the inner surfaces of the cavities.

The piped-rot is one which is readily distinguished from all other diseases of deciduous trees on account of the speckled character of

the affected wood, and it differs very materially from a somewhat similar disease caused by *Stereum frustulosum*, described later on, by the fact that the white areas in the present disease are not sharply defined, but appear as more or less regular white lines in the mass of the wood.

A disease very similar to the one just described for oaks has repeatedly been found by the senior writer in young chestnut trees, particularly in New York and New Jersey. (Pl. V, fig. 2.) In both the chestnut and the oak the disease first manifests itself in the center of the tree, extending outward until it reaches the sapwood. The white masses, consisting of cellulose fibers, are at first confined entirely to the spring wood of each annual ring. As the disease progresses the changes brought about by the fungus spread into the summer wood of each annual ring, and in advanced stages the entire mass of wood fibers is affected.

Trees of all ages having heartwood are affected with the piped-rot. A number of instances were found of young chestnut trees growing in a vigorous stand which were badly diseased when but from 25 to 30 years old. In the case of the chestnut, the disease frequently starts near the ground line, extending up into the trunk. This is probably due to the fact that the fungus causing the disease obtains entrance into the young chestnut through the old stump from which so many young chestnut trees sprout in the form of coppice shoots. In the oaks the disease is more frequently found originating in the top and extending downward into the trunk.

There has been much discussion as to what fungus is responsible for the piped-rot. In a great majority of cases no fruiting body of any fungus can be found on diseased trees. In many localities in Missouri and adjoining States, where the oaks are severely affected, one frequently finds as many as 50 per cent of the young trees of the second growth affected with this disease; but in spite of this fact not a single fruiting body of any form has been found on the trees.

The piped-rot is especially important in the chestnut. Preventive measures with the chestnut involve coating the stumps of old trees with some preservative, such as coal-tar creosote, so as to prevent the entrance of mycelium into the old stump and thence into the young trees growing from the stump. This coating should be applied very soon after the tree is cut, because after the fungus has once obtained a foothold in the stump it is almost impossible to get rid of it. This, of course, will hold only where chestnut regeneration is brought about by coppice formation. In the case of the oaks the preventive measures suggested for the false-tinder fungus will hold good.

SOFT ROT OF OAKS CAUSED BY *POLYPORUS OBTUSUS*.

A number of species of the black oaks, notably *Quercus marilandica* Muench. and *Q. velutina* Lam., are affected with a disease of the heartwood which has been determined by Spaulding (94) to be due to *Polyporus obtusus* Berk. Diseased trees have been found in the eastern part of the United States, and notably in the central Mississippi Valley; a large number of trees are usually found affected in a locality.

The spores of the fungus germinate in the burrows of an oak-boring insect (*Prionoxystus robiniae* Peck.). The fungus grows in the borings

and follows the insect burrow until it reaches the heartwood of the tree; it then spreads out from this point, both up and down the trunk, and gradually brings about a form of soft rot. (Fig. 5.) The diseased wood is lighter in color than the heartwood of the healthy tree, and in its last stages turns almost white. "The diseased wood retains its fibrous appearance, but breaks much easier than does the healthy wood. It does not have the shrinkage cracks which are so characteristic of some of the wood rots; neither does the affected tissue crumble between the fingers nor break very easily into small flakes" (94). The fungus grows in the trees rapidly, extending up and down in the heartwood and growing outward until it reaches the sapwood. Affected trees are weakened to such an extent within one or two years after their first attack that the slightest windstorm causes the trunks to break.



FIG. 5.—A living black oak tree with a sporophore of *Polyporus obtusus* growing out of the opening of an insect burrow.

The sporophore of *Polyporus obtusus* is a very characteristic one. It usually appears at the original insect burrow, where it forms a thick, more or less hoof shaped shelf; in some cases two or three shelves may form, one immediately above the other. The sporo-

phores are almost perfectly white when they first form, but gradually turn darker, and in old age are light brown. The upper surface is very soft and hirsute, and near the point of insertion is much cracked, having the appearance of weathered corn pith. One of the most striking features of the sporophore is the manner in which the rough, hairy upper surface extends over the rounded edge on to the lower side of the sporophore for one-eighth to one-fourth inch or more; the lower surface is the same color as the top. The pores are very irregular in shape, with uneven and jagged edges, giving the whole lower surface a somewhat spiny appearance. The sporophore never attains any great age, because it is attacked with great avidity by various insects which destroy it rapidly.

HEART-ROT CAUSED BY *FOMES NIGRICANS*.

A brown heart-rot of deciduous trees, especially of the yellow birch (*Betula lutea* Michx. f.), willow (*Salix* sp.), and aspen (*Populus tremuloides* Michx.), is due to *Fomes nigricans* Fr. This fungus is found frequently in the Northern States from Maine to Oregon and occurs most often on the yellow birch. Its method of attacking trees, its rate of development, and its spread from tree to tree are very much the same as those described for *Fomes igniarius*.

The fungus is a parasite in the sense that it attacks the heartwood of the tree, gaining entrance through some wound. The decayed heartwood is reddish brown in color, very soft, and has very much the appearance of wood destroyed by *Fomes igniarius*. Lindroth (48) in a recent description of the changes which this fungus brings about in birch wood notes a number of distinct regions of destruction. In the trees examined by the writers they have not been able to differentiate such distinct zones. Plate VI, figure 1, shows a cross section of a thrifty birch tree, in which it will be noted that the destruction is more or less uniform, beginning at the center of the trunk and extending outward almost to the bark. The decayed wood is spongy and will not powder when rubbed between the fingers.

The most striking feature in connection with this type of heart-rot is the extent to which the decay involves the whole trunk. It starts at the center and progresses outward, gradually involves the sapwood, and ultimately reaches the bark, killing the tree. A similar progress of decay involving the sapwood has already been noted for *Fomes igniarius*. This type of disease is very striking in such trees as the paper birch (*Betula papyrifera* Marsh.). The minute changes which take place in wood destroyed by *Fomes nigricans* are of less interest in this connection; they have been fully studied and described by Lindroth in the article already mentioned (48).

The fruiting bodies of *Fomes nigricans* appear on diseased trees as single, large, more or less hoof shaped bodies; there may be but one of these on a tree, or up to six or eight, but in no case is more than one fruiting body found at one point. The sporophores are large, woody structures, resembling those of *Fomes igniarius*. It has been held by Murrill (58) that *Fomes nigricans* is but a form of *Fomes igniarius*.

The top of the sporophore shows a number of concentric ridges in which large numbers of sharply defined shallow fissures appear as the sporophore grows older. These fissures extend radially and transversely across the top and give the appearance of numerous black lines. The top as a whole is smooth, differing in this respect from many types of *Fomes igniarius*, in the older forms of which the top is very rough; the older portions of the surface are jet black. This is likewise usually true of the younger layers, although we have noted instances where the most recently formed outer edge is dark brown in color. One of the most characteristic properties of the top of the sporophore is its intense hardness. When cut into, this hard layer, which is usually about one-sixteenth of an inch in thickness, has a very characteristic horny texture. The lower surface of the sporophore is rounded, and usually dark brown in color; the pores are very minute and regular. The substance of the sporophore is tough and almost woody. The sporophores are of all sizes, varying from an inch to 10 or 12 inches in width. As a rule, when perfect they are characterized by great regularity in their proportions, and when once recognized, one can hardly fail to distinguish this species.

Fomes nigricans sometimes forms very curious fruiting bodies on birches, the cause for which has not yet been definitely determined. For many years observers and collectors in the Northern States have reported finding irregular, black, jagged masses, having the appearance of dried, hard pitch, growing out from wounds on birch trees (Pl. VI, fig. 2). These masses look like large warts. They are jet black in color, very deeply fissured and broken, and of all conceivable shapes. They increase in size from year to year in a very irregular way without any signs of pore formation. The mass of these bodies is very hard and when examined closely shows that it is composed of masses of dark brown hyphæ the walls of which have become excessively thickened, giving the whole a woody texture. The writers have observed these black structures for a number of years without being able to identify them; the senior writer suggested tentatively, some years ago, that they might be undeveloped sporophores of *Fomes igniarius*.

In his recent paper Lindroth (48) describes similar bodies growing on birches in Europe, and definitely calls them abortive bodies of

Fomes nigricans. While there are no signs of pores or other structures which would enable one to definitely say that these black masses are undeveloped sporophores of this fungus, the writers are inclined to agree with Lindroth that this is the case. This supposition is strengthened by the fact that wherever these black masses occur on birch trees the characteristic decay of the wood usually caused by *Fomes nigricans* will always be found. Attention should be called to the very frequent appearance of these sterile masses—a form of growth, so far as known to the writers, which has not been known for any other wood-rotting fungus.

✓ DISEASE CAUSED BY *HYDNUM ERINACEUS*.

The coral fungus (*Hydnum erinaceus* Bull.) produces a white rot of many deciduous species, chiefly of oaks. It has been found abundantly on both the red oak (*Quercus rubra* L.) and white oak (*Q. alba* L.), where its large white fruiting bodies form very conspicuous objects (Pl. VII, fig. 2).

The fungus enters the trees very much as do the other wood-rotting fungi, growing from branch stubs into the heart of the tree. It likewise gets in through the tunnels of the oak borer in the same manner as does *Polyporus obtusus*. The diseased wood in its final stages is soft and mushy, so that when squeezed considerable water flows out. Trees in an advanced state of decay have numerous large holes in the heartwood, which are filled with masses of light yellowish, fluffy fungous mycelium (Pl. VII, fig. 1). During the early stages of the disease the heartwood of the oak turns lighter in color, and the more rapid destruction of the wood between the medullary rays is very characteristic of this type of disease. As the disease progresses, the wood becomes spongy and is practically wholly destroyed, so that cavities such as have been referred to form; indeed, the entire heart of the tree may be destroyed, leaving but a hollow shell consisting of sapwood.

The white rot caused by the coral fungus can be recognized by the very wet, soggy nature of the diseased wood. The fruiting bodies of the coral fungus form on broken trunks and on standing trees, issuing frequently from the holes of the oak borer. They are snow-white in color, anywhere from 1 to 10 or 12 inches in diameter, and almost spherical in shape. They may appear singly or in groups. The mass of the sporophores is fleshy, and drops of glistening fluid frequently exude over the entire surface of the top. The top surface is more or less roughly hairy. The bulk of the sporophore consists of an exceedingly large number of white teeth, or spines, bearing the spores.

Very little is yet known as to the exact distribution of this fungus and of the host trees which it attacks. Judging from the number of

times that the writers have found it, particularly in the central United States, it is fairly common on both the white oak and the red oak.

Trees 50 to 60 years old frequently show the soft heart-rot without any signs of the sporophores. The latter appear to form rarely, and after their formation are very short lived, because they are readily attacked by insects. Even where the insects do not destroy them, they dry up very soon after they have reached maturity, and shrivel into insignificant black masses, which can be recognized with difficulty.

BLACK LOCUST DISEASE CAUSED BY *FOMES RIMOSUS*.

The black locust (*Robinia pseudacacia*) is universally attacked by yellow-rot, which completely destroys the heartwood of living trees. A detailed description of the changes which are caused by this fungus in the wood of locust trees was published by von Schrenk (80). The disease has been found in practically the entire area where the black locust grows, from Massachusetts to New Mexico. It is especially prevalent in the southern Appalachian forests and in some portions of New Mexico, where a very large percentage of the locust trees are destroyed.

Infection takes place through older branches and through the tunnels made by the locust borer (*Cyrtene robiniae*). Wounds are frequent in older trees, caused by the brittle nature of the branches of the locust. The fresh wounds are favorable points for the germination of the spores, and it is an easy matter to find all stages, from trees recently infected to trees where the whole side of a trunk has evidently been infected from one branch. The changes which the fungus brings about in the locust wood are very striking. The hard, resistant wood is transformed into a soft yellow or brown mass, which, when wet, is more or less spongy. The almost flint-like character of the wood is wholly gone in completely decayed wood, which can be cut almost like cheese. (80.)

One of the most characteristic features of the decayed wood is that the decay extends out from the center of the heartwood in a series of radial lines. These radial lines are produced by the fungous threads growing outward through some of the large medullary rays.

The sporophores of *Fomes rimosus* Berk. are large and conspicuous. The mature form consists of one or more broad shelves, the top of which meets the lower side at an angle of from 30 to 35 degrees. They are usually almost twice as wide laterally as from front to back. In the Southern States, and particularly in the Appalachian Mountain forests, the sporophores have a decidedly hoof-shaped character, almost as much so as those of *Fomes fomentarius* (Pl. VIII, fig. 1). Similar hoof-shaped forms have been found by Hedcock in New Mexico. In either form the upper surface in older specimens shows a number of ridges which are very distinct in the younger part of the sporophore, but become almost obliterated as the sporophore grows older. The youngest part of the sporophore shows

a very smooth, rounded edge, which in most cases is light brown, appearing as if polished, or sometimes somewhat villous. The older parts of the upper surface are dark brown, almost black, and are broken into many small pieces by numerous fissures. Many old sporophores have a jagged, extremely rough surface because of these fractures. Lichens and moss frequently cover the older parts. The lower side of the sporophore is dull red-brown and the interior is light brown, with evident, though imperfect, indications of stratification. The pores are continuous through several layers, remaining open for two or three years.

The sporophores often develop from the openings of tunnels of the locust borer or from broken branch stubs. It is not unusual to find eight or ten sporophores on one diseased tree.

Wood which is decayed by *Fomes rimosus* when cut from the tree will remain unchanged for a great many years. In other words, the fungus will not continue to form fruiting bodies on such decayed wood as does the false-tinder fungus previously mentioned. The only preventive measures which can be taken are to care for wounds, and preferably to cut all locust trees before they reach an age where their branches begin to break off in large numbers. For most localities this will be from sixty to seventy-five years.

WHITE HEART-ROT OF ASH CAUSED BY *FOMES FRAXINOPHILUS*.

A disease caused by *Fomes fraxinophilus* Peck upon white ash (*Fraxinus americana* L.) in the Mississippi Valley has been described in a previous publication by von Schrenk (84). It attacks white ash trees of all ages, usually those, however, which are more than 7 inches in diameter. The fungus is a distinct wound parasite, the parasite starting its development in a branch stub, whence it grows into the heartwood of the trunk. The diseased wood first of all turns darker in color. The next stage of the disease is marked by a bleaching of the color in the spring wood of the annual rings; these gradually turn back to the original straw color, and then white in spots. Ultimately the whole tissue becomes a loose, spongy mass of wood fibers. The completely rotted wood is straw colored, very soft and nonresistant, and readily absorbs water.

The sporophores of *Fomes fraxinophilus* appear at the base of branch stubs or in wounds, either alone or several together. The mature sporophore is nearly triangular in cross section; it has a broad, rounded edge, which at first is white and gradually turns darker until it becomes somewhat straw colored. The older portions of the upper surface are dark brown or black and are very hard and woody. The younger part grows out over the older portions, which makes the sporophore look somewhat sulcate. The main

body of the mature sporophore is very hard and woody. It is obscurely zoned, pale brown and rust colored.

The white ash disease is one that can be combated with success provided careful attention is given to protecting wounds. Vigorously growing trees appear to be particularly susceptible to the disease, since where one diseased tree occurs those in the immediate vicinity are very likely to become infected shortly after. The cutting out of all trees which show signs of sporophore formation is therefore recommended.

RED HEART-ROT OF BIRCH CAUSED BY *FOMES FULVUS*.

A heart-rot of the river birch (*Betula nigra* L.) has been found repeatedly in Missouri and Arkansas. It is caused by *Fomes fulvus* Fr., which is apparently the fungus which causes such an extensive destruction of the olive trees in Italy. It has been reported in this country on a number of hosts, but especially on the river birch.

The sporophores generally grow near a branch stub. They are very woody and hard. The young sporophore appears as a small knob, which gradually increases in size and when mature is almost triangular in the cross section. The upper surface is at first rough or hairy, but later becomes perfectly smooth and almost flinty in texture. A number of very fine irregular fissures form on the upper surface in older sporophores, extending parallel to the edge. The upper surface never becomes deeply fissured and broken, as in *Fomes ignarius* and *F. rimosus*. The upper surface when mature is a dull red-brown; the lower surface is very smooth and joins the upper at an angle of about 30 degrees. The pores are extremely minute, hardly visible to the naked eye. The mass of the sporophore is very hard and woody and shows decided evidence of stratification. No detailed investigations have as yet been made as to the nature of the decay induced by the fungus. Diseased trees show a brown rot of the heartwood extending for some 10 or 12 feet both up and down from the points where the sporophores are growing. The wood has a red-brown appearance and crumbles to pieces when crushed. There are no signs of felt-like sheets such as occur in similar brown-rotted wood when destroyed by the sulphur polyporus (*Polyporus sulphureus*).

SOFT HEART-ROT OF CATALPA CAUSED BY *POLYSTICTUS VERSICOLOR*.

The hardy catalpa (*Catalpa speciosa* Warder) is affected with but one very serious disease, which has been described at length by von Schrenk (83). In the early stages of the disease the wood near the center of the tree becomes discolored, and this discoloration gradually

spreads outward. The discolored areas gradually disintegrate until the wood becomes straw-yellow. In the final stages of the disease the entire heartwood becomes converted into a soft rotted mass which resembles pith in its consistency.

The catalpa disease is caused by *Polystictus versicolor* Fr. The spores of this fungus germinate in some wound, or generally at a branch stub. The fungus grows through the stub and spreads up and down in the trunk. After a time fruiting bodies form on the outside of the trunk, generally near a branch wound. The sporophores are sessile and a great many of them grow together, one above the other. They are readily recognized by the soft, hairy upper surface, with alternate bands of light and dark color. The margin of the sporophore is irregularly wavy when dry. Fresh sporophores are fleshy, but as they grow older they become tough and somewhat brittle, and the front edge curls in.

Hardy catalpa trees are affected early in life. In the instances described the trees were about 18 years old. In order to prevent the spread of the disease most attention should be paid to the careful coating of all wounds made in pruning or in cutting off root suckers.

✓ HEART-ROT OF OAKS CAUSED BY *FOMES EVERHARTII*.

Fomes everhartii Ellis & Galloway (16) has been found repeatedly growing on blackjack oak (*Quercus marilandica* Muench.), causing a disease almost indistinguishable from that described for the false-tinder fungus (*Fomes igniarius*). Affected trees frequently show in a very striking manner that the mycelium of this fungus is capable of growing into the sapwood of the living tree (Pl. III, fig. 2). In the upper part of the figure it will be noted that the fungus has destroyed not only the heartwood but has extended through the sapwood, where it has evidently been growing for about three years, as indicated by the callous formation on the edges of the diseased part.

The sporophores of *Fomes everhartii* are large, conspicuous woody bodies which grow out from wounds. They are generally broad, of a dark rusty brown color, with a deeply cracked and fissured upper surface. The lower surface is red-brown in color, with extremely minute round pores.

WHITE-ROT CAUSED BY *POLYPORUS SQUAMOSUS*.

Buller (9) has recently described a white-rot of deciduous trees caused by *Polyporus squamosus* Huds., which occurs upon the maple (*Acer pseudoplatanus* L., *A. platanoide*s L., *A. saccharinum* L., *A. negundo* L.), pear (*Pyrus communis* L.), oak (*Quercus* sp.), elm (*Ulmus montana* With.), walnut (*Juglans regia* L.), linden (*Tilia europaea* L.),

willow (*Salix* sp.), ash (*Fraxinus excelsior* L.), birch (*Betula* sp.), horse chestnut (*Aesculus hippocastanum* L.), and beech (*Fagus sylvatica* L.). Buller's descriptions refer especially to the occurrence of this disease in Europe; and although the writers have found the same but rarely in this country, it occurs now and then in the Northern States. Freeman (23) mentions its occurrence in Minnesota, although he states that it is usually found on dead logs or stumps. In view of its widespread occurrence in Europe on living trees, it is probable that it will be found in this country more frequently than is known at the present time.

According to Buller, diseased maple wood becomes much whiter than the normal wood. Irregularly scattered series of white lines appear in the diseased wood, resembling the decay brought about by *Fomes applanatus* as described by Heald (38).

The fruiting bodies are almost circular and are attached to the trunk of the tree by a marked stipe. They grow to a considerable size, individuals 1 foot in diameter not being at all infrequent, and Buller mentions a sporophore which measured 2 feet 2 inches across. He states that they are remarkable for their rapid rate of growth.

The fruiting bodies are annual and are produced from May until September. They are at first soft and juicy, but as they grow older and drier they become very tough. The upper surface is characterized by the presence of a series of large scales, which give it a roughened appearance. Buller states that when a tree has been killed by *Polyporus squamosus* the fungus can still continue its annual production of fruiting bodies.

TWO SAP-ROTS.

In addition to the fungi which have been previously described, there are two forms which are usually considered parasitic on deciduous forest trees. These are *Fomes fomentarius* (L.) Fr. and *Polyporus betulinus* (Bull.) Fr. Both of these fungi are very common all over the Northern Hemisphere, and both of them have been described by various authors (Tubeuf (102), Mayr (53), Hartig. (34, 35), Freeman (23), et al.) as parasitic on living trees. The manner in which they attack trees, however, is so different from that described for the fungi which cause distinct heart-rots of living trees that they should be considered in a separate group.

In spite of numerous observations which the writers have made for years upon these two fungi, they are not prepared to class them with the preceding forms, nor can they state definitely that they should be considered as parasitic on living trees. Distinction between a parasitic fungus growing on a forest tree and one growing as a saprophyte is a difficult matter. The writers have attempted to make two

groups—one including those fungi which gain entrance through wounds or branch stubs and grow in the heartwood of the living trees; the other, those fungi which grow on dead wood, including both wood removed from the living tree and in some cases dead heartwood or sapwood actually exposed to the air, but still forming a part of the living and actively growing tree. While the first class is not distinctly parasitic in the ordinary sense that a rust is parasitic on a living leaf, the fungi are nevertheless always associated with living trees, and their mode of life may be called parasitic.

Fomes fomentarius and *Polyporus betulinus* rarely, if ever, cause a heart-rot; that is, they rarely gain entrance through a branch stub into the center of the tree and cause a type of decay starting at the center and extending outward. Both of them are found as frequently (and probably in the greater number of cases) on dead trees or logs as they are on living trees. The writers have found both of these forms growing on living and on dying trees, but they are unable to say whether these trees were weakened by the fungi or whether the fungi were able to grow upon the trees because they were already weakened by other causes. The sporophores of both of these fungi grow in large numbers on standing dead trees, and they have frequently been held responsible for the death of trees. The most exhaustive investigation of one of these fungi was made by Mayr (53), who transplanted wood infected by the mycelium of *Polyporus betulinus* into the sapwood of healthy trees and found that in a period from August to November the mycelium had grown 2½ centimeters into the sound wood around the point of infection. He regards this as evidence of the parasitic nature of the fungus, but the final results should be known before passing judgment upon his experiments.

In view of the common occurrence of these fungi, they are described with the expectation that further investigation may decide their true nature.

DECAY CAUSED BY FOMES FOMENTARIUS.

Fomes fomentarius (L.) Fr. occurs in the United States mainly on the beech (*Fagus atropunicea* (Marsh.) Sudworth) and the yellow birch (*Betula lutea* Michx. f.), but it also occurs on other deciduous species. The sporophores are distinctly hoof shaped. They appear as small rounded knobs on the surface of the trunk; that is, they are not confined to branch stubs, but occur also at other wounds. Their upper surface is smooth and more or less definitely marked by concentric ridges. The older sporophores are uniformly gray and have a somewhat powdered appearance. The lower surface is red-brown and shows numerous regular small round pores. The

margin of the newer layer is grayish white and very soft and velvety. The sporophores usually occur singly, although two or more may grow into an irregular mass where they grow out from the trunk in close proximity to one another. A diseased trunk bears from one to twenty or more of the sporophores scattered over the surface. The decay induced by *Fomes fomentarius* starts in the outer sapwood immediately under the bark, and proceeds inward until it reaches the center of the tree. (Pl. VIII, fig. 2.) The decayed wood is characterized by numerous irregular black lines, bounding areas of wood not yet completely decayed. Wholly rotted wood is very soft and spongy, light yellowish in color, and crumbles between the fingers into numerous separate wood fibers.

Beech and birch trees are usually decayed in the tops, and the fungus gradually spreads down toward the base of the trunk. It is no unusual sight to find a large tract of birches weakened by forest fires in which almost every tree has from two to ten sporophores of this fungus growing at various heights from the ground. In northern New England, New York, Michigan, Wisconsin, and Minnesota in particular, the tinder fungus (*Fomes fomentarius*) is one of the commonest wood-destroying forms found in deciduous forests. It grows with great rapidity in dead wood. Beech or birch trees which have been felled are rapidly destroyed by the mycelium of this fungus. The mycelium will develop in large masses from cut surfaces of trunks infected therewith when placed in moist surroundings. This power on the part of the mycelium to flourish away from the standing tree is very characteristic of this species and also of *Polyporus betulinus*.

DECAY CAUSED BY POLYPORUS BETULINUS.

So far as known *Polyporus betulinus* (Bull.) Fr. occurs only on species of birch. It is widely distributed in Europe and Asia and all over the northern part of North America, including the northern United States. In this country it occurs on the yellow birch (*Betula lutea* Michx. f.), the paper birch (*B. papyrifera* Marsh.), and the white birch (*B. populifolia* Marsh.). The fruiting bodies form half-rounded, conspicuous brackets, which start as small rounded knobs, usually growing out through a lenticel. These knobs rapidly expand until they form a hemispherical papery sporophore. (Pl. IX, fig. 1.) The upper surface is very smooth, usually dirty white in color, with no signs of marks or cracks; it resembles a very thick, stiff piece of pasteboard. The outer margin is round and is usually more or less white wherever the thin, dark outer layer has peeled off. The rounded margin extends down on to the lower surface, forming a decided ridge around it. The lower surface is yellowish

to brown in color. The pores are irregularly jagged and toward the outside assume a more or less horizontal position. The sporophores grow to be large—in some cases as much as 12 inches in diameter. They are annuals and are usually short lived, because they are attacked by insects with avidity.

The decay caused by the birch fungus is very similar to that described for *Fomes fomentarius*. The fungus gains entrance through the bark, probably through the lenticels or wounds, and starts growing in the outer sapwood, progressing inward toward the center. (Pl. IX, fig. 2.) The decayed wood is very uniformly yellowish in color and shows numerous cracks extending both radially and tangentially throughout the mass. Badly decayed wood crumbles into a fine powder, and differs in this respect from birch wood destroyed by *Fomes fomentarius*. Mayr (53) discusses the various microscopic changes caused by this fungus in birch wood, treating not only the morphological but also the chemical changes induced by this fungus.

Wherever birch trees are weakened either by fire or other causes, the birch fungus will attack them with great rapidity, and it must be considered as one of the most destructive fungi to birch wood.

SAP-ROTS OF SPECIES OF DECIDUOUS TREES.

The line between those fungi which are capable of growing on dead wood that has died after being cut from a living tree and the fungi which grow on dead wood of the still living tree can not be sharply drawn. Certain of the wood fungi cause disease while the tree is still standing, and where such fungi have universally been found associated with a certain type of disease the evidence is strong that the fungus causes the disease.

In many recent descriptions of diseases of forest trees reference is made to fungi which in the opinion of the writers must be considered strictly saprophytic forms which occur only on dead wood. A striking instance of this is *Fomes applanatus* (Pers.) Wallr. This fungus is frequently found on living trees, but a careful examination always shows it to be growing on wood which is actually dead, and generally on the dead outer sapwood. So far as the writers have been able to observe *Fomes applanatus* does not cause what may be called a disease of living trees. The same is true of many other fungi—for instance, *Daedalea quercina* (L.) Pers., *Polystictus pergamenus* Fr., *P. hirsutus* Fr., *Poria vaporaria* Fr., *Polyporus gilvus* Schweinitz, and *Stereum frustulosum* Fr. It is natural that observers should describe some of these fungi as being responsible for diseases of the living tree, because they occur frequently on standing trees which are but partially alive. The writers believe, however, that most of these forms, if not all, will not grow on a tree until it has already been so weakened

by other factors that to all intents and purposes it is dying or dead, with the possible exception of cases where the fungi grow on dead patches of wood caused by some injury, as in the case of trees injured by fire.

SAP-ROT CAUSED BY *POLYSTICTUS VERSICOLOR*.

Of all the fungi which grow upon the deciduous species of woods after they are cut from the tree the most widely distributed, and in many respects the most destructive, is *Polystictus versicolor* (L.) Fr. Either singly or in dense masses its varicolored sporophores may be found on any of the deciduous species in all parts of the world. So far as known, this fungus is a strict saprophyte, except where it causes the destructive heart-rot of the catalpa. This fungus grows universally throughout the United States, and probably in all parts of the world. It is extremely common in Canada, Mexico, and Europe; it is known from Africa to Australia, and it has been reported from Japan, the Canary Islands, the West Indies, and South America.

Polystictus versicolor is one of the most cosmopolitan species of fungi known. It does not seem to have any preference for any particular kind of wood, but grows with almost equal readiness, especially on the sapwood, on every broadleaf species of wood (as distinguished from coniferous wood) known. On account of its wide geographical range and its ability to grow on and destroy so many different kinds of wood, it should be regarded as the most serious of all the wood-rotting fungi which attack the dead wood of broadleaf trees. It is the fungus which destroys probably 75 per cent or more of the broadleaf species of timber used for tie purposes. Wherever broadleaf species of wood are used for fencing, for posts or poles, or for any purpose where they come in contact with the soil they are sure to be attacked sooner or later by *Polystictus versicolor*.

The fruiting bodies of this fungus are extremely variable, depending upon the kind of wood upon which they grow and upon the conditions under which they develop. The sessile sporophores may grow singly or, more usually, many of them together, forming a series of closely overlapping shelves. As just indicated, they are readily recognized by the soft, hairy upper surface with bands of various colors. These bands are usually white and yellow, although considerable variation from both of these colors will be found. When young the sporophores are fleshy, but they become tough and leathery when older. The lower side of the sporophore is generally snow white, and the pores are exceedingly regular and minute. The body of the sporophore is very thin, rarely exceeding the thickness of heavy paper.

In the majority of cases the sporophores form on a vertical surface and spring from a broad sheet of mycelium which covers the entire

surface of the timber upon which they happen to be growing. They form readily in a moist atmosphere. They first appear as tiny masses of mycelium, which grow out usually from the medullary rays, and generally several within a small area. These small masses rapidly grow larger, until in the course of a few days they have united in a single mass visible to the naked eye. After they reach the size of one-eighth inch in diameter, or thereabouts, the hymenial layer begins forming on the lower surface of the knob. A mature fruiting body may be formed in about a week where the fungus is in a condition for rapid development.

The young sporophores seem at first to grow perpendicularly from the surface from which they protrude, irrespective of whether this be



FIG. 6.—An oak railroad tie with fruiting bodies of *Polystictus versicolor*.

a horizontal or a vertical surface. Very soon after their appearance, however, the shelves assume a horizontal position. Where wood is placed in contact with the ground, the sporophores are frequently cramped and crowded by soil or stones, and in such cases the growing mycelium adapts itself to the available space and produces sporophores of every conceivable shape and size. It is not at all uncommon to find large masses of the sporophores forming in the upper surfaces of cinder ballast on railroad tracks. The mycelium in this case binds the individual cinders together, forming great clumps 6 or 8 inches in diameter. Where two or more sporophores start on a surface in close proximity they will as a rule fuse before reaching maturity, and as a result of this fusion long sheets may form composed of two or many sporophores which have grown together laterally (fig. 6).

Polystictus versicolor usually starts its development in some season check, although it may start to develop on the surface of a stick of wood provided the same is kept in moist surroundings. The spores

germinate where a sufficient amount of water and air is available, and the rapidly growing hyphæ spread through the wood, starting with the medullary rays. The fungus first of all attacks the sugars and starches stored in the sapwood, and then it attacks the woody fiber itself.

The character of the growth of *Polystictus versicolor* is well shown in figure 6. In its early stages the affected wood usually becomes paler in color, and following very soon after this bleaching effect the wood begins to take on a disintegrated appearance, so that it becomes what is known popularly as "punky." It has lost all of its usual characteristics of hardness and strength and has turned into a soft, dry, nonresistant, pithy mass, which is usually more or less straw colored.

The minute changes which take place in the wood fiber consist of a rapid solution of various parts of the woody structure in its entirety. In other words, the fungus has no special preference for either the lignin or cellulose parts of the cell wall. Now and then one may find a condition in the last stages of decay in which some of the wood fibers have become delignified. When such wood is stained with chloriodid of zinc the whole wall of certain groups of wood fibers seems to be corroded away. In badly decayed wood the only parts of the original cell which remain recognizable are those parts of the original walls common to two or three cells. Among the partially consumed fragments of the original wood cells one may find scattering complete cells; in fact, there is no difference in the extent and degree of decay in different parts of the same annual ring. The more open spring wood falls apart more readily because of its porous nature, but no evidence has been obtained that it decays more rapidly than the denser summer wood. The changes just referred to are practically the same for all classes of woods affected.

Like all sap-rotting fungi *Polystictus versicolor* is especially dependent for its development upon the presence of a sufficient quantity of water and air. It will usually grow with the greatest vigor close to the surface of the soil. Its fruiting bodies may therefore be looked for at or near the ground line on ties, poles, posts, and all timbers exposed to the soil. Where wood has time to dry out partially on the outside after it is cut, the spores will not usually germinate on the outside, on account of lack of water. Infection of such partially dried wood usually takes place through some season check.

This fungus may start development in a stick of wood within a few weeks after it has been cut; or, in other words, shortly after the wood becomes sufficiently dry on the outside to form season checks. After it has once gained entrance below the surface, the mycelium will grow vigorously in the wood and give absolutely no evidence of its

presence on the outside until the wood has become sufficiently decayed to permit of the formation of sporophores, which then usually form by growing out through the season checks to the outside air. It is on account of its ability to produce decay in the interior of the stick of wood that this fungus is so very destructive, and it is for this reason that the greatest care should be taken to guard against its possible entrance. In moist climates the fruiting bodies will form above the ground on wood which may be several feet above the soil. Where wood has a chance to have air circulate around it continuously, however, the possibilities that it will become infected with this fungus are remote.

The decay which *Polystictus versicolor* brings about in wood is usually confined for a year or more to the sapwood, and in many species it is wholly confined to the sapwood. This is true of such trees as have their heartwood sharply differentiated from their sapwood, as in the oaks (*Quercus* spp.), black walnut (*Juglans nigra* L.), red gum (*Liquidambar styraciflua* L.), etc. In woods where the differentiation between heart and sap wood is indistinct, as in the tulip poplar (*Liriodendron tulipifera* L.), willows (*Salix* spp.), and cottonwood (*Populus deltoides* Marsh.), the fungus brings about the destruction of the sapwood with great rapidity, and even destroys the heartwood, although this takes place more slowly. Between these two extremes there are many gradations. Sapwood of the white ash (*Fraxinus americana* L.), yellow birch (*Betula lutea* Michx. f.), and beech (*Fagus atropunicea* (Marsh.) Sudworth) is rapidly destroyed, but the heartwood resists the attacks of this fungus for a considerable period of time, although not so long as does the heartwood of the oaks. The rate at which the sapwood of different broadleaf species decays presents little variation. It may be stated as a general rule that the sapwood of all trees is very susceptible to the attacks of *Polystictus versicolor* and that where any difference in the resisting power of such woods to this fungus occurs it will be in favor of the heartwood.

Measures for preventing or arresting the development of *Polystictus versicolor* will be considered later, together with other sap-rotting fungi, because preventives which apply to this fungus will apply to practically all of the sap-rotting forms.

SAP-ROT CAUSED BY POLYSTICTUS PERGAMENUS

A second form of sap-rot of great importance is caused by *Polystictus pergamenus* Fr. This fungus, while usually found on dead wood, may now and then occur on living trees where these have been severely injured. It is one of the forms which frequently appear on standing trees after forest fires have killed certain parts of the

trunk. The forest fire may not seem to have injured the tree at the time, although the heat may have been sufficient to kill the cambium layer over a considerable area. The bark over such areas dries out and cracks, and it is in such dead bark that this fungus finds a favorable entrance. Within a few months after the injury the sporophores of *Polystictus pergamenus* are found growing on the dead bark, and the decay caused by the fungus extends rapidly throughout the deadened area (fig. 7). In almost any burnt area of deciduous forest one may find many of the standing trees after a year or two bearing large masses of the sporophores of this fungus.

Polystictus pergamenus is universally distributed throughout the United States and Canada, and it is known from various points in South America. It grows on practically all the deciduous species of wood. It is very common on species of oak and has been collected by the writers on the following woods: Red gum (*Liquidambar styraciflua* L.), white oak (*Quercus alba* L.), scarlet oak (*Q. coccinea* Muench.), red oak (*Q. rubra* L.), black-jack oak (*Q. marilandica* Muench.), shingle oak (*Q. imbricaria* Michx.), sugar maple (*Acer saccharum* Marsh.), silver maple (*A. saccharinum* L.), red maple (*A. rubrum* L.), yellow birch (*Betula lutea* Michx. f.), chestnut (*Castanea dentata* (Marsh.) Borkh.), shagbark hickory (*Hicoria ovata* (Mill.) Britton), tulip poplar (*Liriodendron tulipifera* L.), black cherry (*Prunus serotina* Ehrh.), beech (*Fagus atropunicea* (Marsh.) Sudworth), and willow (*Salix* sp.).



FIG. 7.—A living tree of red oak the bark of which was killed by fire. The fungus *Polystictus pergamenus* is rapidly rotting the sapwood beneath.

The general appearance of wood decayed by this fungus is very similar to that destroyed by *Polystictus versicolor*. The microscopic changes differ in certain respects. A cross section of oak wood cut so as to include both healthy and badly decayed wood shows areas of the wood fibers, especially in the summer wood of the annual ring, which are colorless, while the other parts of the section are more or less yellow. The colorless parts are the rotted regions, and in very badly affected wood they may include all of the wood fibers in an annual ring. The vessels and the medullary ray cells, however, retain their color and appear unaffected. When stained with cellulose reagents like chloriodid of zinc the colorless areas stain deep blue. From this it appears that the fungus removes the lignin elements from the cell walls. In the worst affected areas the cells are broken down still further and the walls appear broken and corroded, so that little remains except small fragments of the cell walls with the pieces of the middle lamella which are located at the corners of these cells embedded within them, and the whole held together by masses of fine fungous hyphæ. The medullary ray cells resist the action of the fungus longer than any other part, very much as is the case in the form of decay caused by *Polystictus versicolor*.

The rate of decay caused by this fungus is very much like that described for *Polystictus versicolor*. Small pieces of oak wood inoculated with spores of the fungus have been completely rotted in about three months. The rate of decay varies with the amount of water left in the wood, the air supply, and the temperature.

The relative resistances of heartwood and sapwood to the attacks of this fungus are very similar to those already referred to for *Polystictus versicolor*, and the same may be said of the relative resisting power of different species of woods, so far as known at this time.

The fruiting bodies of *Polystictus pergamenus* occur throughout any deciduous forest tract. A large number usually grow together, one above the other, and not infrequently they are joined laterally so as to form long series of shelves. The body of the pileus is leathery and rigid; the top is concentrically sulcate, generally white when young, growing grayish when older; the upper surface is slightly hairy; the lower surface is generally purplish in color; the pores are small and the intervening walls become much torn and lacerated, so that in older specimens they resemble teeth or spines.

SAP-ROT CAUSED BY FOMES APPLANATUS.

In a recent paper Heald (38) describes a disease of the cottonwood due to *Fomes applanatus* (Pers.) Wallr., which he, however, calls *Elfvringia megaloma* (Lév.) Murrill. He finds that cottonwood trees are affected with a disease which attacks both heart and sap wood and

results in their gradual destruction, ultimately causing the death of the entire tree. The injury to the wood is only local, occurring generally near the base of the trunk. The fungus is said to enter the trunk through injuries near the ground line or through wounds on the roots, and "spreads upward through the entire wood, reaching, in specimens observed, the height of 10 feet. The entire wood of the lower portion of the trunk becomes thoroughly infected before the fungus obtains sufficient vigor to produce its external fruiting bodies. In this condition the wood is rendered very brittle, and the tree thus affected is poorly fitted to withstand the force of the wind in severe storms" (38).

The diseased wood is characterized by the appearance of numerous localized pockets, separated from one another by wood which the fungus has evidently not been able to destroy. Heald states that the fungus is probably only a facultative parasite and "is not able to attack young, healthy trees, but that it can become parasitic on older trees in which the vitality has been considerably lowered, or that have reached the maximum of their development."

The writers have repeatedly observed this form of decay in the cottonwood, but in their experience it usually starts near the base of the trunk in large wounds caused by fire or otherwise. On that account they are not inclined to call this decay of the cottonwood a disease in the sense in which the decays induced by *Fomes igniarius*, *F. fraxinophilus*, and others are diseases. There are a large number of species of fungi which, like *Fomes applanatus*, grow on dead wood and which may now and then grow on living trees. All of these, including *Fomes applanatus*, can grow just as well and apparently better on wood after it has been cut from liv-



FIG. 8.—A dead stub of a maple tree bearing fruiting bodies of the sap-rot fungus (*Fomes applanatus*).

ing trees, and should, in the opinion of the writers, be considered as saprophytic forms. (See fig. 8.)

DECAY CAUSED BY *STEREUM FRUSTULOSUM*.

Stereum frustulosum (Pers.) Fr. and other species of *Stereum* cause the destruction annually of large quantities of structural timbers. The fruiting bodies of this fungus are very insignificant and generally escape the attention of the casual observer. They appear in the form of small, slightly elevated gray spots on the surface of decaying wood. In the majority of instances they look like sheets of cracked mud, the individual pieces separated by the cracks vary-



FIG. 9.—A piece of oak timber rotted by *Stereum frustulosum*. The fruiting bodies are the lighter colored, irregular, small bodies which are seen thickly scattered over the surface.

ing in size from one-sixteenth to one-fourth of an inch in diameter. Figure 9 shows a piece of red oak (*Quercus rubra* L.) with the fruiting bodies of this fungus.

Wood decayed by *Stereum frustulosum* can always be recognized by the peculiar pocket-like formation in the mass of the wood. Fungi like *Polystictus versicolor* produce a form of rot in which the entire mass of the wood is affected. *Stereum frustulosum*, on the other hand, causes changes in the wood fiber in localized areas of the wood. The holes are more or less lens shaped and are separated from one another by sound layers of wood fiber. The lining of the holes is usually composed of a layer of white cellulose fibers. *Stereum frustu-*

losum occurs on practically all of the oaks, and probably on other broadleaf species. It is sometimes found growing in wounds on living trees, but is strictly confined to dead wood. It is widely distributed in the United States and is one of the chief fungi destroying oak wood.

SAP-ROT CAUSED BY DAEDALEA QUERCINA.

One of the most important enemies of structural oaks (*Quercus* spp.) and chestnut (*Castanea dentata* (Marsh.) Borkh.) is *Daedalea quercina* (L.) Pers. Plate X shows an end view of a white-oak tie with the sporophores of this fungus; also a section of the same tie 2 feet from the end. This fungus has a world-wide distribution. It is one of the most common forms on oak and chestnut logs, ties, telegraph poles, fence posts, bridge timbers, etc., all of which it destroys with rapidity. The conditions favoring the spread of this fungus, the manner in which the wood is infected, and the rate of growth are in a general way very similar to those described for the two preceding fungi. The sporophores form either singly or in groups. They are sometimes found growing out from large wounds upon the sapwood of standing trees; hence, this fungus has been frequently described as one causing a disease of living trees. The sporophores are tough and rigid, with a corky consistency. They are first white in color, but gradually turn darker to a gray; the upper surface is zonate; the pores are elongated and have a wavy outline.

The wood decayed by this fungus is generally moist and mushy, but on drying becomes harder, although when rubbed between the fingers it crumbles into a fibrous mass.

OTHER SAP-ROTTING FUNGI.

In addition to the sap-rotting fungi referred to there are a large number which grow more or less frequently on broadleaf species of wood. Their number is so large that it is impossible to refer to all of them here, and only a few of the more typical ones can be mentioned. Among these are the following: *Polystictus hirsutus* Fr., *P. sanguineus* (L.) Mey., *P. cinnabarinus* (Jacq.) Fr., *Poria subacida* Peck., *P. vaporaria* Fr., *Polyporus betulinus* (Bull.) Fr., *P. gilvus* Schwein., *P. adustus* (Willd.) Fr., *Lenzites corrugata* Klotzsch, *L. vialis* Peck., and *L. betulina* (L.) Fr.

All of these forms and many others grow singly or, more frequently, in masses on dead wood, which they destroy with varying degrees of rapidity. The manner in which they enter the wood and the rate of growth differ slightly for the different forms, but for practical purposes they need not be distinguished from *Polystictus versicolor* and *P. pergamenus*. Detailed studies of most of these forms are yet to be made. Some of the forms which attack beech wood have recently been described by Tuzson (103).

DECAY OF STRUCTURAL TIMBER.

After the wood from any of the broadleaf trees has been cut from the tree and it is exposed to the air or soil, decay occurs sooner or later. Different species show a varying power of resistance to decay when thus exposed, and as a result of this difference these woods are usually classed into long-lived and short-lived woods. The long-lived woods possess natural inherent qualities which enable them to resist the attack of decay for a comparatively long period. In comparison with many coniferous woods, the broadleaf species have a very much smaller power to resist decay, and the number of them which are long lived is rather few. Among those woods which may be considered very long lived are the catalpa (*Catalpa speciosa* Warder), black locust (*Robinia pseudacacia* L.), and Osage orange (*Torylon pomiferum* Raf.). Woods like the white oak (*Quercus alba* L.), chestnut (*Castanea dentata* (Marsh.) Borkh.), and shagbark hickory (*Hicoria ovata* (Mill.) Britton) come next in durability; while among the very short lived woods, the willows (*Salix* spp.), cottonwood (*Populus deltoides* Marsh.), beech (*Fagus atropunicea* (Marsh.) Sudworth), and tupelo gum (*Nyssa aquatica* L.) may serve as examples.

CAUSES OF DECAY.

The decay of wood after it has been cut from the living tree may be due to a number of causes. It may crumble away because of influences usually referred to as "weathering." Wood fiber when exposed to the air and to frequent wetting by rain is worn away mechanically, giving the surface a roughened appearance. The wood of most broadleaf species after being exposed turns grayish white in color on the outside, due to the separation of groups of wood fibers which stand out from the surface and give it a more or less hairy appearance.

The principal cause of decay is the growth of certain saprophytic fungi in the wood fibers, which as a result of their growth bring about changes in the wood which alter its structure and tensile quality.

FACTORS FAVORING DECAY.

The factors which favor the decay of wood in general have been repeatedly referred to (79, 81) as (1) a certain amount of water, (2) a certain amount of heat, (3) a certain amount of air, and (4) a certain amount of food supply. Where one or more of these four factors are absent, decay will not be possible, because the growth of the wood-destroying fungi is prevented.

RATE OF DECAY.

The rate of decay varies according to the species of wood and the part of the tree from which it is taken. Sapwood decays very much more rapidly than heartwood. In many broadleaf species the sapwood may be attacked by one or more of the wood-destroying fungi within a few weeks after the wood is cut. The most notable examples of the rapid decay of the sapwood are to be found in timbers like beech (*Fagus atropunicea* (Marsh.) Sudworth), red oak (*Quercus rubra* L.), and chestnut (*Castanea dentata* (Marsh.) Borkh.). The relation which the presence of organic matter in the sapwood has to its decay has been a much discussed question. It has generally been thought that sapwood will decay most rapidly when cut from the tree during the period when the organic matter, such as starches and sugars, is present in the largest quantities and is being actively

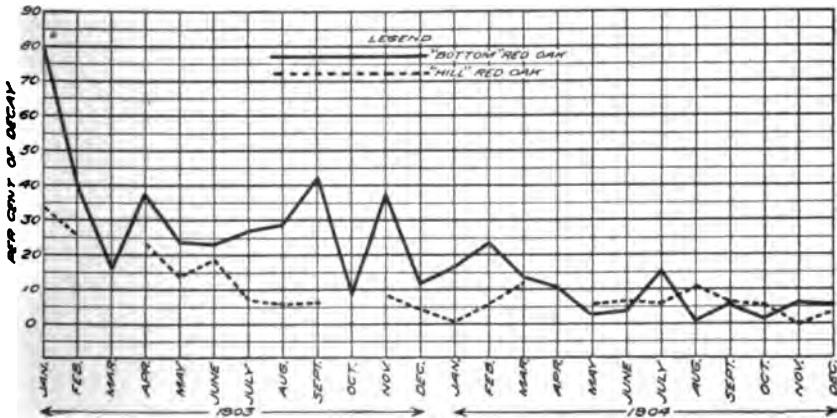


FIG. 10.—Diagram showing relative rate of decay of 2,400 pieces of "hill" and "bottom" red oak. Countings made April 26, 1906.

formed by the tree; that is, during the spring and early summer. This has given rise to the almost universal practice of requiring structural timber to be cut during the winter period, in order to insure a long life.

From a number of experiments made on a large scale with red oak the writers found that the idea that material cut in the winter was less susceptible to fungous attack certainly did not hold in all cases. Reference to figure 10 shows that red-oak timbers cut in November, 1903, decayed more rapidly than did similar timbers cut from the same land and piled in the same locality in June, 1903. While this single experiment does not necessarily show that summer-cut wood is preferable to winter-cut wood, it indicates very clearly that many of the ideas held for a long time as to the relative value of winter and summer cut wood deserve more extensive and careful investigation.

MANNER OF INFECTION.

One of the most practical questions in connection with the decay of sapwood of broadleaf species, as well as of conifers, deals with the manner in which the sapwood becomes infected with the fungus. With the possible exception of some of the fungi referred to in a previous part of the bulletin, such as *Fomes igniarius* and *Polyporus sulphureus*, most of the fungi which bring about the decay of structural timber do not grow in living trees. The heartwood of the living tree is accordingly free from the supposed germs of decay, and wherever any decay does take place the spores of the fungi responsible for the same must get into the wood from the outside.

Although this has been very definitely shown to be the case, there is still a very widespread belief among timbermen that decay starts in the interior of the stick. This has arisen from the fact that pieces



FIG. 11.—Cross section of an oak railroad tie rotted by one of the sap-rot fungi. Note the season crack through which the fungus obtained entrance to the interior.

of wood may appear perfectly sound on the outside and still may be wholly decayed in the inner part. In figure 11 a striking example of this is shown. This figure shows a section taken from a piece of "bottom" red oak cut in May, 1904. The timber was piled in the open, and the section here shown was taken in 1906. It will be noted that the outer quarter of an inch of wood appears perfectly sound and that immediately inside this sound layer the wood has been completely decayed. There was absolutely no external sign on this timber which would indicate that it was not sound throughout. Instances of this kind are numerous and they naturally give rise to much apprehension on the part of the purchaser of timber, because it is not practicable to cut into timbers for the purpose of determining whether they are sound on the inside.

The explanation for this form of sap decay is briefly as follows: When the stick of wood (fig. 11) was cut it was perfectly green and full of water. It was piled so that it was exposed on all sides to the wind and sun. As a result of this exposure the outer layers of the wood fiber dried very rapidly, and the amount of water left in the outer layers was insufficient for the development of the wood-destroying fungus. As a result of the drying, small season checks formed on the outside, one of which will be noticed in the middle at the top of the photograph. The season check penetrated into the interior for an inch or two; then some of the spores of the fungus lodged in it and there was still sufficient moisture to enable the spore to germinate and grow. The fungus then rapidly spread through the wet sapwood near the bottom of the season check, bringing about the decay shown in the figure. This decay would have gone on until all of the sapwood was destroyed, and fruiting bodies would then have formed on the outside in one of the season checks.

A very familiar instance of this kind of internal decay can be found in any forest where the stumps of trees are examined a year or more after the trees have been felled. The cut surface of the stump will appear season checked, but otherwise sound. When bored into, however, the wood within about a half inch of the upper surface of the stump will usually be found completely decayed. The realization that sap-rot in timber is due almost wholly to the action of fungi the spores of which enter through season checks and develop in the sapwood when it is not allowed to dry out is one of the most important practical considerations in connection with the entire study of the diseases of woods.

SUSCEPTIBILITY TO DECAY.

The same species of wood will show differing tendencies toward decay, according to the localities in which the trees are grown. This is well illustrated by the difference in lasting power which is found in so-called "hill" and "bottom" red oak (*Quercus rubra* L.). Hill red oak grows very much more slowly than bottom red oak, forming a denser grained, heavier wood, which is less permeable by water. In figure 10 the results of an extensive experiment comparing hill and bottom red oak are shown. This figure shows the results of exposing some 2,400 pieces of hill and bottom red oak. One hundred pieces were cut every month, beginning in January, 1903, and continuing until December, 1904. Two tracts of land were selected—one on which the hill variety grew and the other some 50 miles away, on which a dense bottom red-oak stand was growing. All of the timbers were piled in a similar manner and were left for observation.

With the exception of several months' cut of the hill red oak, the programme was carried out for two years. The numbers at the left of the figure indicate the percentage of timbers upon which masses of wood-destroying fungi were growing and which were obviously decayed to a greater or less extent. No account could be taken of internal decay, as just referred to, where no sporophores were formed, because it was not possible to cut into the pieces.

Figure 10 shows one thing very strikingly, namely, the greater percentage of decay in bottom red oak than in hill red oak. This is especially noticeable for certain months—for instance, August and September, 1903, where in the case of the bottom red oak 28 and 42 per cent, respectively, were decayed, while with the hill red oak but 6 per cent were decayed. When exposed for but a brief period of time, the difference between the two timbers is not so striking, as is shown by the last months included in figure 10. This is readily explained by the fact that the decay had not advanced far enough for the formation of fruiting bodies of the fungus, except in those timbers where infection first took place. If the timbers cut in June, July, August, etc., had been left as long as those cut the year before, the difference would probably have been equally as striking as during 1903.

PREVENTIVE METHODS.

The prevention of decay due to one or the other of the fungi just described may be brought about in one of two ways: First, by placing the wood under such conditions that the wood-destroying fungi can not develop; second, by treating the wood with chemical preservatives which act as poisons for the wood-rotting fungi. Both of these methods are successful, and it is usually necessary to employ both in conjunction.

One of the most important preliminary steps in the handling of timber after it is cut from the log is to dry it out as rapidly as possible. The drying process should aim to remove the water as equably as possible from all parts of the stick, so that excessive checking may not result. Where the drying does not take place uniformly, infection by sap-rotting fungi occurs, as has been most strikingly shown (fig. 11). All wood should be kept from contact with the soil for a certain period after it is cut from the tree, and only after it has been thoroughly dried should it be thus exposed.

Where wood is to be chemically treated, especially those species which are very susceptible to sap-rotting fungi, like the red oak (*Quercus rubra* L.), beech (*Fagus atropunicea* (Marsh.) Sudworth), red gum (*Liquidambar styraciflua* L.), etc., the greatest care should be used to pile the wood so that no two pieces shall touch more than is absolutely necessary. Timbers should, furthermore, not be piled

for too long a period, because, so far as known up to this time, the only safe method for avoiding the chance of getting sap-rotted pieces, such as shown in figure 11, is to chemically treat the wood before the fungus has had an opportunity of getting a foothold.

Where large timbers are used, it is always well to lessen the chances of internal decay, or so-called dry-rot, by building composite timbers. Some recent striking instances were noted in a large building where 12 by 12 inch oak timbers were used for posts and beams. One of the wood-destroying fungi had gained entrance through the lower ends of some of these vertical posts, had grown up through them without any signs on the outside, and had infected the horizontal beams. The decay had proceeded from the cellar to the tenth story of the large factory building. The discovery of the decayed condition was made when a hole was bored into one of the timbers for the purpose of inserting a screw; the timbers were then removed, and it was found that they had entirely decayed with the exception of a shell of about an inch in thickness on the outside. In reconstructing this building oak timbers were used, but instead of using 12 by 12 inch pieces for posts they were made of four 3 by 12 inch pieces bolted together. The chances for internal decay of such posts will be much lessened. The most efficient method for preventing the decay of timber consists in chemical treatment. References to this subject will be found in the bibliography appended hereto (12, 13, 14, 15, 28, 29, 64, 81, 85, 86, 90, 91, 103, 108).

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PLATES.

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DESCRIPTION OF PLATES.

- PLATE I. *Frontispiece*. A tree of aspen (*Populus tremuloides*) bearing several sporophores of *Fomes igniarius*. The tree is badly rotted within, and the fungus has formed its fruiting bodies at old knot holes left by the dying of small lateral branches. The tree is still alive, but is sure to die within a few years.
- PLATE II. Effect of *Fomes igniarius* upon living trees. Fig. 1.—Cross section of the trunk of a tree of silver maple (*Acer saccharinum*) which bore but one fruiting body, this being the only external indication of disease. Note the black, narrow zones surrounding the completely decayed wood; also the place of entrance at the upper right-hand corner produced by the rotting of a dead lateral branch. Fig. 2.—Cross section of a living tree of aspen badly diseased with the white heart-rot. Note concentric, dark zones surrounding the diseased part.
- PLATE III. Decay of living trees caused by wound fungi. Fig. 1.—Cross section of a living tree of beech (*Fagus atropunicea*) decayed by *Fomes igniarius*. This tree bore but a single fruiting body, this being the only external indication of disease. The decay extended about 4 feet both upward and downward from the sporophore. Fig. 2.—Cross section of the trunk of a living red oak (*Quercus rubra*) rotted by *Fomes everhartii*.
- PLATE IV. *Polyporus sulphureus*. Fig. 1.—A large compound fruiting body of *Polyporus sulphureus*, such as is very often found. Fig. 2.—Cross section of the trunk of a living tree of post oak (*Quercus minor*) rotted by *Polyporus sulphureus*.
- PLATE V. Piped-rot. Fig. 1.—Longitudinal section of the trunk of a living tree of black jack oak showing the piped-rot. Fig. 2.—A piece of chestnut wood diseased with the piped-rot.
- PLATE VI. *Fomes nigricans*. Fig. 1.—Cross section of the trunk of a living tree of paper birch (*Betula papyrifera*) diseased by *Fomes nigricans*. Fig. 2.—The trunk of a paper birch (*Betula papyrifera*) showing an irregular aborted sporophore of *Fomes nigricans* growing at an old wound.
- PLATE VII. *Hydnum erinaceus*. Fig. 1.—Cross section of the trunk of a living tree of white oak (*Quercus alba*) with the heartwood rotted by this fungus. Note below, at the left, two burrows of the oak borer through which this fungus probably entered. Fig. 2.—Fruiting body of *Hydnum erinaceus* growing in a hollow oak trunk.
- PLATE VIII. *Fomes fomentarius*. Fig. 1.—Sporophores growing upon a dead tree of beech (*Fagus atropunicea*). Fig. 2.—Cross section of the trunk of a dead beech tree with the sapwood rotted by this fungus; the heartwood is practically sound.
- PLATE IX. *Polyporus betulinus*. Fig. 1.—A dead trunk of yellow birch (*Betula lutea*) with a large sporophore of *Polyporus betulinus*. This fruiting body measured about 1 foot in diameter. Fig. 2.—Cross section of the trunk of a dead yellow birch tree with a fruiting body of *Polyporus betulinus*. The wood is entirely rotted.
- PLATE X. *Daedalea quercina*. Fig. 1.—An oak railroad tie with fruiting bodies of *Daedalea quercina*. The tie is badly decayed within. Fig. 2.—A section of the above tie 2 feet from the end bearing the fruiting bodies of the fungus. It will be noted that in the lower part it is quite seriously affected.

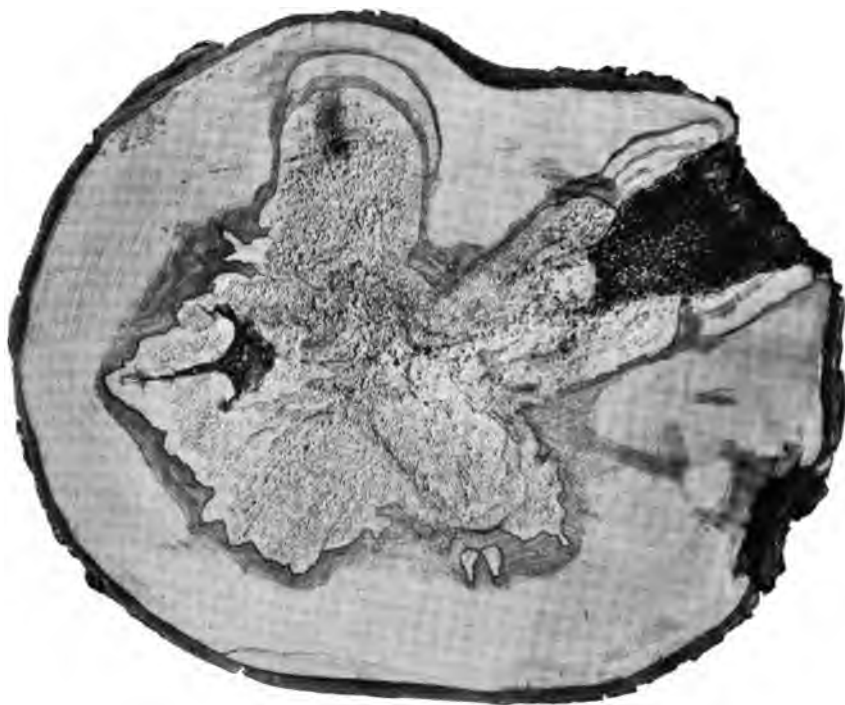


FIG. 1.—CROSS SECTION OF THE TRUNK OF A LIVING SILVER MAPLE ROTTED BY *FOMES IGNIARIUS*.



FIG. 2.—CROSS SECTION OF A LIVING ASPEN TREE ROTTED BY *FOMES IGNIARIUS*.

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FIG. 1.—CROSS SECTION OF A LIVING BEECH TREE DISEASED BY
FOMES IGNARIUS.



FIG. 2.—CROSS SECTION OF A LIVING RED OAK TREE ROTTED BY
FOMES EVERHARTII.

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FIG. 1.—FRUITING BODY OF POLYPORUS SULPHUREUS.



FIG. 2.—CROSS SECTION OF A LIVING POST OAK TREE ROTTED BY POLYPORUS SULPHUREUS.

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FIG. 1.—PIPED-ROT OF OAK.



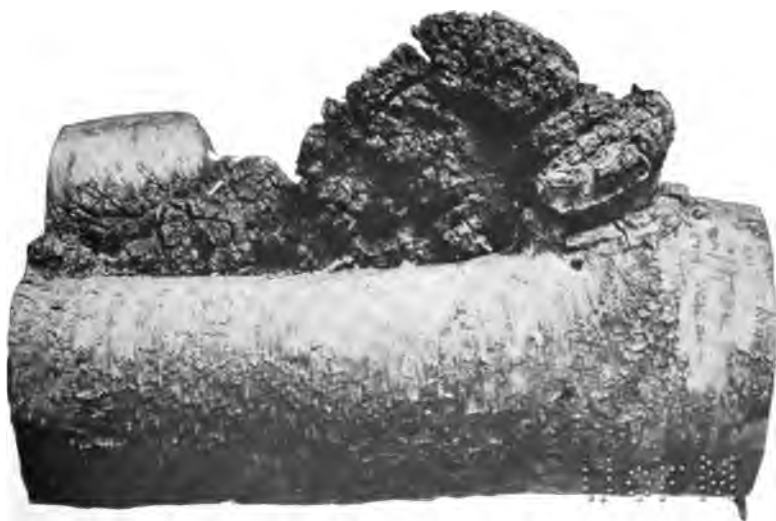
FIG. 2.—PIPED-ROT OF CHESTNUT.

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FIG. 1.—CROSS SECTION OF A PAPER BIRCH TREE ROTTED
BY *FOMES NIGRICANS*.



FIG. 2.—AN ABORTIVE FRUITING BODY OF *FOMES NIGRICANS* UPON A LIVING TREE OF PAPER BIRCH.



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FIG. 1.—CROSS SECTION OF A LIVING WHITE OAK TREE DECAYED BY *HYDNUM ERINACEUS*.



FIG. 2.—FRUITING BODY OF *HYDNUM ERINACEUS* IN A HOLLOW LOG.

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FIG. 1.—A DEAD BEECH TREE WITH SPOROPHORES
OF *FOMES FOMENTARIUS*.



FIG. 2.—CROSS SECTION OF A DEAD BEECH TREE
ROTTED BY *FOMES FOMENTARIUS*.



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FIG. 1.—A DEAD YELLOW BIRCH TREE WITH FRUITING BODY OF POLYPORUS BETULINUS.

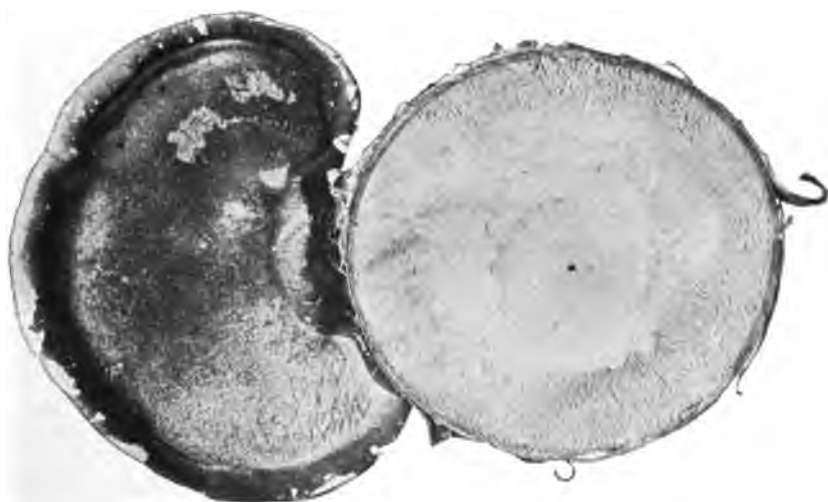


FIG. 2.—CROSS SECTION OF YELLOW BIRCH TREE ROTTED BY POLYPORUS BETULINUS.

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FIG. 1.—AN OAK RAILROAD TIE ROTTED BY *DAEDALEA QUERCINA*.

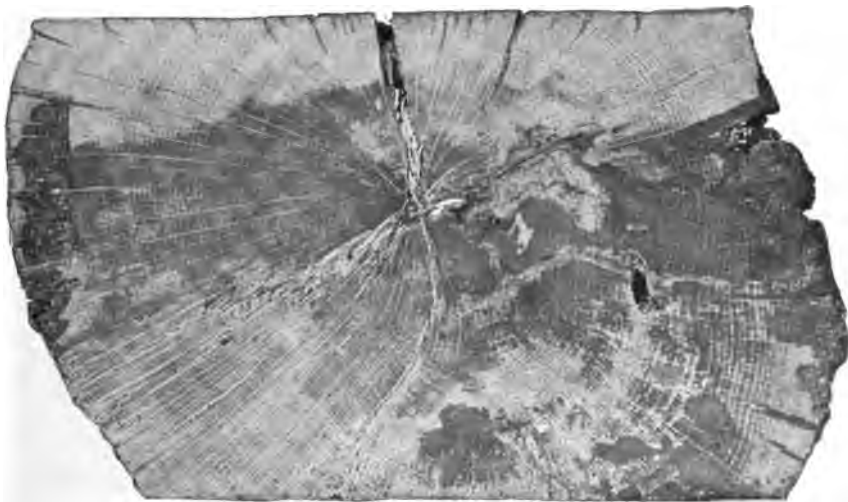


FIG. 2.—CROSS SECTION OF THE TIE SHOWN IN FIGURE 1, TWO FEET FROM THE FRUITING BODY.

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FIG. 1.—AN OAK RAILROAD TIE ROTTED BY *DAEDALEA QUERCINA*

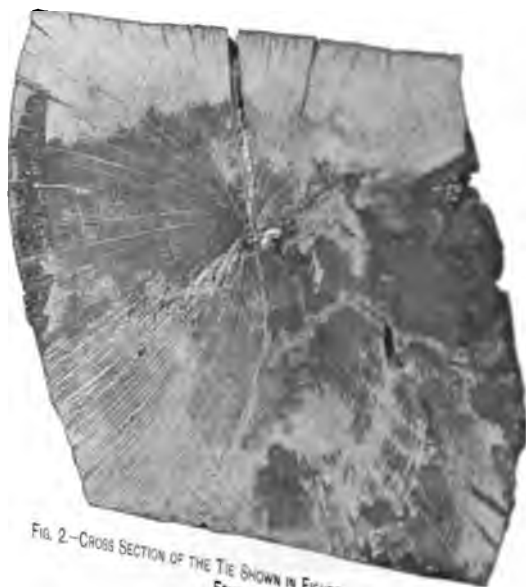


FIG. 2.—CROSS SECTION OF THE TIE SHOWN IN FIGURE 1, TWO FEET FROM THE FRUITING BODY.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 150.

B. T. GALLOWAY, *Chief of Bureau.*

THE WILD ALFALFAS AND CLOVERS OF SIBERIA,
WITH A PERSPECTIVE VIEW OF THE
ALFALFAS OF THE WORLD.

BY

N. E. HANSEN,

AGRICULTURAL EXPLORER OF THE UNITED STATES DEPART-
MENT OF AGRICULTURE; PROFESSOR OF HORTICULTURE
IN THE SOUTH DAKOTA STATE COLLEGE OF AGRI-
CULTURE AND MECHANIC ARTS.

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FOREIGN SEED AND PLANT INTRODUCTION.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., February 27, 1909.

SIR: I have the honor to transmit herewith the manuscript of a paper by Prof. Niels Ebbesen Hansen, Agricultural Explorer of this Department and Professor of Horticulture in the South Dakota State College of Agriculture. The manuscript is a preliminary report on the wild alfalfas and clovers of Siberia, with a perspective view of the alfalfas of the world.

During the past twelve years Professor Hansen has made three trips to the colder regions of Europe and Asia in search of new alfalfas and other forage crops. The report deals with questions bearing on the crops discovered and introduced, and is respectfully recommended for publication.

On behalf of Professor Hansen I wish to express thanks for the great courtesy and kindness of all Russian officials and other citizens of the Empire of Russia, who did everything in their power to assist in his work.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE WILD ALFALFAS AND CLOVERS OF SIBERIA, WITH A PERSPECTIVE VIEW OF THE ALFALFAS OF THE WORLD.

INTRODUCTION.

On February 10, 1909, the writer returned to Washington from an eight months' tour to Siberia and Turkestan as Agricultural Explorer for the United States Department of Agriculture. This concluded his third tour to Siberia in search of a hardy alfalfa for the Prairie Northwest. These three expeditions were preceded by a visit to European Russia in 1894.

It had been his plan to say very little concerning the new plants obtained until they had been further tested, preferring that the seeds should tell their own story as to their value for this continent. However, the flood of correspondence indicates such great interest in this subject that it appears desirable at this time to present a preliminary report.

THE PREPARATION FOR THE WORK.

Upon entering the Cabinet in 1897, Secretary Wilson mapped out a comprehensive system of foreign explorations by which the number of economic plants now in cultivation in various parts of the United States was to be largely augmented by additions from other countries having similar conditions of soil and climate.

The writer had the honor to be appointed the first agricultural explorer. Three years previously, in the course of a four months' trip through eight countries of Europe, he had spent three weeks in European Russia studying the horticulture and agriculture of that empire. The trip served to direct his thoughts into unusual channels, especially in the line of breeding hardy fruits. This breeding work has occupied his attention ever since, and after raising seedlings by the hundreds of thousands some remarkable hybrids have been originated.

This line of breeding has led the writer to study the habitat and original distribution of many economic plants and to do considerable work in exploring our western wilds, where an occasional rattlesnake would add zest to the quest. The wise counsel of his teacher, Prof. J. L. Budd, and his observations from a trip through Russia gather-

ing fruits in 1882 have been remembered with great profit. Since September, 1895, in the writer's work at the agricultural college and experiment station of South Dakota, this question has continually presented itself: Why are some plants hardy and other plants tender as regards winter cold and summer heat? There must be some definite law underlying this great difference in hardiness.

THE FIRST JOURNEY TO SIBERIA.

The writer's first journey to Siberia was a ten months' tour, from June, 1897, to March, 1898, through eastern European Russia, Turkestan, western China, and Siberia. (See Pl. I.) As a result of this journey Turkestan alfalfa was imported into the United States for the first time. The exportation of Turkestan alfalfa, both to North and South America, has since assumed large proportions, as it has been found in certain localities to be more resistant to cold and drought than the ordinary alfalfa now in cultivation, which was brought by the Spaniards from North Africa to South America, perhaps three centuries ago, and later to California.

The trip of 1897 included an overland journey by wagon and sleigh of over two thousand miles from Tashkend, Turkestan, to Omsk, Siberia, via Kuldja, western China. Five carloads of various seeds and plants were obtained in the course of the ten months' tour.

The endeavor of 1897, as developed in the progress of the investigation, was to find the northernmost plants of *Medicago sativa*, the common alfalfa now cultivated. As nearly as could be determined, the northern limit was near Kopal, in southwestern Siberia. The severity of the winter made further work by the writer impossible. At one time he was one thousand miles from the nearest railroad. The hardships and perils of that journey are a matter of record.

At that time the writer had come to believe strongly that the botanical name of any species of plant was not enough for the purposes of agriculture; that a species extending over a wide geographical range differed widely in degrees of hardiness, especially in regard to cold; and that for the northern regions of the United States we must find the form that had been developed by nature in similar regions in the Old World. Hence the endeavor to get the most northern type of alfalfa in Asia for trial under similar conditions in North America, where no alfalfa is native.

THE SECOND JOURNEY TO SIBERIA.

Circumstances made it impossible for agricultural explorations to be resumed in Siberia for some time. The Spanish-American war, the Russian-Japanese war, and the Russian revolution all made



further work impracticable. In July, 1906, the second journey began, and this turned out to be a six months' trip around the world by way of England, Denmark, Lapland in northern Norway and Sweden, Finland, Siberia, Manchuria, and Japan. Some three hundred lots of various seeds and plants were obtained on this journey.

The writer learned that he was very nearly correct in his former estimate as to the northern limit of the common alfalfa in Asia, but that extending far north of this limit across Siberia were three wild species with yellow flowers instead of blue and that these were good forage plants in the driest and most severe regions of southern Siberia. The early settlers of Siberia learned the value of these species, as they put up wild hay for the stock and observed that the cattle, sheep, and horses on the ranges were fond of these plants. These three species were *Medicago falcata*, extending approximately over the western two-thirds of Siberia; *Medicago platycarpa*, found in a much more limited range in central and south-central Siberia, especially along the edge of timber and in timber clearings; and *Medicago ruthenica*, found in the remaining eastern portion of Siberia, Mongolia, and Manchuria. Associated with these were some wild clovers which it appeared equally desirable to obtain, especially for short rotations.

The lateness of the season when these species were found made it impossible to obtain the seed of more than one of the three, *Medicago falcata*. The intense interest manifested in this discovery upon returning to the United States showed the urgent need of hardier alfalfas and clovers than we now have for the prairie regions of the Northwest.

THE THIRD JOURNEY TO SIBERIA.

The third journey, of eight months, was for the purpose of gathering more seed of new forage plants, especially alfalfas and clovers, in Siberia. As the route homeward was through the Caucasus, the Mediterranean region, and North Africa, the writer was able to make a study of some other alfalfas, so that the present report might be termed a perspective view of the alfalfas of the world, or a study of alfalfa on four continents, especially the wild alfalfas of Siberia and the cultivated alfalfas native to Turkestan and the Mediterranean region. It is the story in brief outline of a persistent and determined effort to find out what nature has done toward making the alfalfa family adapted to regions of extreme cold, heat, and drought.

This third tour to Siberia was very greatly hampered by unfavorable weather; it was the wettest and most backward season known for many years and the seeds were not ripe at the usual time. The widespread epidemic of Asiatic cholera in Russia and Siberia, in

the midst of which the writer had to labor, did not facilitate the work. Some 300 lots of seeds and plants were obtained, however. On this journey a study was made of how people manage to live in some of the principal deserts of the world, including the Gobi Desert of Mongolia, the Salt Steppes of southern and southwestern Siberia, the Hunger Steppe of Turkestan, and the Sahara Desert of North Africa. An effort to extend this knowledge has been made by studying the work of numerous Russian explorers in Siberia and central Asia, so as to get a wider grasp of the subject. The remarkable fact developed that one alfalfa and one clover grow nearly, if not quite, at the northern limit of cold. This point is Verkhoyansk, in latitude 68° north, with a recorded minimum temperature of -67.8° C. (-90.04° F.). Yakutsk is in 62° north latitude, nearly due north of Lake Baikal, with a recorded minimum temperature of -64.4° C. (-83.92° F.). The northeastern limit of *Medicago falcata* and of *Trifolium lupinaster* is somewhere between Verkhoyansk and Yakutsk. Specimens of both plants have been collected on the Aldan River north of Yakutsk. In this region the subsoil remains permanently frozen.

In this extreme northern section of Siberia throughout an immense area are found the remains of the huge mastodons which at one time roamed over the plains. Their ivory tusks are still found in large quantities and are utilized, although usually much weathered after so many centuries of exposure.

It is of great interest to note that nature has furnished two legumes for this extreme north region. The mastodons of a former age have been succeeded by the hardy breeds of cattle and reindeer kept by native tribes and exiles. The time available, as well as his own preference, made the writer gather seeds in latitudes farther south, from 50° to 55° north, where with hot and dry summers there is much less snow at the time of the lowest temperatures, the mercury in the thermometers sometimes freezing with no snow on the ground.

In studies as to the sources of the seed the important fact should be borne in mind that the mere latitude and longitude do not tell the main story, but that isothermal lines and the amount of precipitation are the main factors in indicating climatic extremes. These have been the main guides in choosing the localities in which to gather seeds.

A FORECAST.

The writer has often been urged to make positive statements as to what the alfalfas and clovers brought from Siberia will do under field culture in the various regions of the United States. Inasmuch as he is not a prophet nor the son of a prophet he has steadily refused to do this. To the farmers of the Northwest who have lost millions

in all these years by the winterkilling of the common alfalfa and clover imported from the far milder regions of the Old World, he must give the admonition to be patient until the Department of Agriculture can definitely determine the value of these and other new introductions for the various regions of the Northwest.

The great difficulty of gathering seed in quantity in the wilderness makes it impracticable to send out the seeds to private planters, nor would it be desirable to do so until their real value has been determined. From a study of the climatic and soil conditions under which the seeds were gathered in Siberia, there are excellent reasons for believing that they will be found valuable in the colder and drier regions of the Northwest. They are not intended for regions where no trouble has been experienced from winterkilling of alfalfas and clovers under ordinary conditions. For such regions the writer would say, "Let well enough alone." His own belief is that these new plants will extend the present alfalfa and clover limits as far north on the American continent as anyone will wish to farm.

These alfalfas and clovers may be used in two ways: (1) As a cultivated crop for hay and pasture, and (2) to introduce as wild plants into the native ranges of the Prairie Northwest, where they will probably be able to hold their own with any plants now found there. As regards food value the peasants of Siberia have long ago determined that these alfalfas are suitable for all kinds of stock. *Medicago falcata*, especially, is no doubt an important factor in making the rich cream and butter for which Siberia is becoming noted.

THREE SIBERIAN ALFALFAS.

There are upward of 50 species of *Medicago* distributed through middle and southern Europe, especially in the Mediterranean region, western Asia, and North Africa. The group includes the useful snail clovers. Some are objectionable owing to their spiny pods, which cause trouble by getting into the wool of sheep.

The genus is well represented in the Caucasus, where there are at least 21 native species, along with 54 species of *Trifolium*, and there is abundant room for further explorations, especially in the mountain regions, for new species.

MEDICAGO FALCATA.

Geographical distribution.—*Medicago falcata* L., the name, "falcata" referring to the falcate or sickle-shaped pods, is distributed over a very wide area of Europe and Asia, but in the milder regions of its habitat it has been overshadowed by the common lucern, which has been under cultivation for a much longer period. It extends through a large part of western Europe, central and southern

Russia, the Crimea, the Caucasus, and through approximately the western two-thirds of Siberia, at least as far as 64° north latitude, through North China, the Trans-Caspian regions, including Turkestan and Persia, and through Afghanistan, western India, and Asia Minor. The extraordinarily wide distribution of this plant makes it necessary to be extremely careful in choosing the source of seeds.

Sir J. D. Hooker, in his "Flora of British India," states that the plant is found in Kashmir, Ladak, Kunawar, etc., and at an altitude of 5,000 to 13,000 feet in Afghanistan.

Moorcoft, in his article on the fruit trees of Kashmir, July 8, 1823, gives interesting notes on the cultivation of this yellow lucern in northwestern India. In a letter written in 1822 Moorcoft says that "the yellow lucern is a spontaneous production of this, is of a constitution more hardy than that of Europe, requires no other culture than that necessary for sowing it, and lasts for a long series of years."

This yellow-flowered lucern is considered by some authors to be the ancestor of the common alfalfa, but if so it must have been derived from the form of the species as found wild in its far south range, where civilization flourished in the earliest times. The Chinese have cultivated *Medicago sativa* from very early times and have *Medicago falcata* in cultivation in North China south of the Trans-Baikal region. However, this is far south of the region in which the writer secured seed in 1906 and 1908.

Medicago falcata in European Russia.—The agricultural experiment station at Besentsug, some 30 miles east of Samara in the Volga River region of eastern European Russia, is in the midst of a vast steppe region which has suffered from severe summer droughts and winter colds, often with but little snow. Recurring failures of crops have caused widespread distress at times among the peasants. This station has been recently established to help solve the dry-land agriculture problems for this region. *Medicago falcata* is found native here, and attention has been turned to it very recently as a valuable native plant adapted to cultivation. The trials at this station show that *Medicago sativa*, the French lucern as it is called in Europe, winterkills frequently and does not endure pasturing, while the native alfalfa, *Medicago falcata*, is of course perfectly hardy and endures pasturing for ten years at least. Under culture the plant is of upright habit except the first season, when it is somewhat reclining. It is a long-lived plant with a strong root system. The roots have been traced to a length of 10 feet and were still vigorous. Chemical analyses show that the protein content of the first cutting is superior by nearly 2 per cent to that of the common alfalfa, but in later cut-

tings the reverse is the case. Hence, it would seem best to cut early. Stock are very fond of this wild alfalfa.

The small experimental plots of the native form of *Medicago falcata* in southern European Russia in the Poltava and Kharkof provinces showed a strong upright growth, as strong as ordinary alfalfa (*Medicago sativa*). However, *Medicago falcata* is not cultivated to any extent in this region because the ordinary alfalfa has the start of it as a cultivated plant and the seed is plentiful and cheap.

At Moscow and other regions of western Russia where the climate is moister, clovers are more profitable in their shorter rotations than alfalfas.

Klingen, the Russian agronomist, found as many as one hundred branches from one plant of *Medicago falcata*. Where not pastured the plant is of strong, upright growth, standing fully waist high in the steppes, but where pastured closely it creeps and only the ends are erect. In general, Klingen finds that *Medicago falcata* stands pasturing, while *Medicago sativa* does not.

Medicago falcata is considered an excellent plant for bees, the flowers containing an abundance of nectar.

In his 1906 expedition the writer secured seed of *Medicago falcata* from Kharkof Province, southeastern Russia, S. P. I. No. 20717; from Omsk, Siberia, S. P. I. Nos. 20718 and 20719; from Irkutsk, eastern Siberia (from a load of wild hay), S. P. I. No. 20720; Samara Province in the Volga River region, S. P. I. Nos. 20721 and 20726; Saratov Province, central Volga River region, S. P. I. No. 20722; Don Province of the lower Volga River region, southeastern Russia, S. P. I. No. 20725; and Tomsk, Siberia, S. P. I. No. 20724.

Siberian field notes on Medicago falcata made in 1906 and 1908.—In 1906 and 1908 the writer found *Medicago falcata* to be a long-lived perennial with yellow flowers and with such a strong upright growth that it could be easily cut with a mower. Seed of this plant was gathered in many localities in 1906 from various parts of the Volga River region of eastern and southeastern Russia and in 1908 from a good many places ranging from the western boundary of Siberia to the Chinese border in the Trans-Baikal region, a distance of about 4,000 miles, but especially in the provinces of Tomsk, Akmolinsk, and Irkutsk. The choice of localities was decided by their similarity to the region of the Prairie Northwest, in which the alfalfas were designed to be tested. This species is especially abundant in the provinces of Tomsk and Akmolinsk, western Siberia. In 1908, traveling by wagon from Biisk to Semipalatinsk, in the vast plain lying just north of the Altai Mountains, which separates it from Mongolia, the writer learned in the course of a drive of 400 miles that *Medicago falcata* is one of the dominant and characteristic plants

of the steppe pastures and open range, holding its own with all the other vegetation. An abundance of hay is put up by the peasants, and the plant is highly esteemed in the wild pastures and ranges.

Wherever the range is not greatly overcrowded, especially with sheep, *Medicago falcata* is a fine upright plant 3 to 3½ feet in height. The abundant, bright yellow flowers are decidedly ornamental. Stock eat this plant greedily, and bees work on it industriously. It has a very strong root system. At 3 feet the taproot of one plant was still as large as a lead pencil.

The land here is divided into fenced tracts. Each village has one tract, usually greatly more than sufficient for its needs, but the population is rapidly increasing by immigration from European Russia.

Medicago falcata is a common plant in the wild hay offered for sale in the hay markets of the small towns along the line of the Siberian Railroad. The common name given it by the peasants is "scholtse veseel," the first word meaning yellow, but "veseel" is sometimes applied to a vetch and to a clover in other regions of Russia.

In August, 1908, the writer found wild plants of *Medicago falcata* 5 feet 8 inches in length near Semipalatinsk. This was on the banks of the Irtysh River in sandy soil mixed with some clay. In the open steppe 3 to 4 feet was a common height.

Medicago falcata is a very common wild plant all through this region. The peasants have so much land that they have not begun the cultivation of any alfalfas or clovers and will not need to with the present scarcity of population and as long as *Medicago falcata* is so abundant.

The personal observation of the writer was that horses, cattle, and sheep are extremely fond of the plant, and that it endures considerable pasturing. It was also learned that it is green very early in the spring, endures very severe summer droughts, stands dry upland soils underlaid with hardpan, and is considered resistant to alkali in the salt steppes of the south part of the Tomsk Province.

In 1906 the writer found this plant quite abundant on the eastern coast region of Lake Baikal in eastern Siberia, and a quantity of the seed was saved from hay brought in by the Buriats, a Mongolian tribe, from north of Irkutsk. The proximity of this great lake gives a greater rainfall here than out on the steppes, so that this form of the species may prove desirable in moist, cold regions such as Maine and northern Michigan. Lake Baikal may be termed approximately the eastern limit of the plant, although it was found in abundance at Werchne Udinsk, about 100 miles east of the lake. The extreme eastern point where it has been found is at Charonte, a few miles into Chinese territory, where an arm of the Gobi Desert extends across the Siberian Railroad.

MEDICAGO PLATYCARPA.

Medicago platycarpa Ledebour is a strong-growing perennial alfalfa with yellow flowers and large flat pods, found mainly in central Siberia. Its distribution is principally along the edges of timber and in open places in the native timber. Its native environment indicates that it should be tested in some sheltered regions, such as the timber sections of northern Minnesota and Wisconsin and westward into the Rocky Mountains. It is found in south-eastern Siberia from the Province of Tobolsk west to Irkutsk and south into Mongolia, its main distribution, however, being in the southern part of the Province of Tomsk. In this province seed was gathered in 1908 at Chylim, east of the Obi River.

MEDICAGO RUTHENICA.

Medicago ruthenica Ledebour is a yellow-flowered wild perennial alfalfa extending approximately from the eastern shore of Lake Baikal to the Pacific Ocean; in Siberia extending southward into Manchuria, Mongolia, Korea, and northern China. Its northern limits, from the specimens collected so far, appear to be the central part of the Amur River and its tributaries. Seed was gathered the past season at Charonte, in an arm of the Gobi Desert, a few miles east of the Chinese border in the Mongolian portion of Manchuria. Manchuria proper begins in the Chingan Mountains, farther east. Here this plant was abundant and growing in nearly pure sand. In general it is found scattered in dry, stony soils. *Medicago ruthenica* is closely related to *Medicago falcata*, but the seed pods are flat and oval or tapering slightly at both ends, much like those of *M. platycarpa*, but smaller.

As a fodder plant this species is greatly relished by the cattle, horses, sheep, and camels kept by the native nomad Mongolians in the region where the seed was gathered. Its distribution in a general way may be said to be north of that of the common alfalfa (*Medicago sativa*).

The botanical descriptions indicate, as far as length of stem is concerned, that the three Siberian alfalfas, *Medicago falcata*, *M. platycarpa*, and *M. ruthenica*, are the same in length of stem, being given as 75 to 100 centimeters. The stems of *M. platycarpa* and *M. ruthenica* are smooth; those of *M. falcata* are somewhat hairy. The flowers of all three are yellow. The pods of *M. platycarpa* and *M. falcata* contain many seeds; those of *M. ruthenica* not usually more than four seeds. The seed pods of *M. falcata* are sickle shaped, while those of the other two are flat and somewhat oval.

FOUR OTHER ALFALFAS.

MEDICAGO SATIVA.

The common alfalfa, or lucern, is a native of the temperate regions of western Asia. According to Watt^a the botanical evidence favors the inference that the original habitat of this plant extended from the northwest frontier of India to the shores of the Mediterranean. Watt further says that many writers regard *Medicago sativa* L., *M. falcata* L., and *M. media* Persoon as forming but one species. Other writers hold them to be varieties of one species, and still others believe that all three are distinct. Stebler and Schröter very justly maintain that to the agriculturist all three are very distinct. The ancient Indian literature is too vague to separate these alfalfas fully, so Watt describes all Indian notes without specific botanical distinction as to the species to which they allude. Stebler and Schröter state that lucern is indigenous to Asia, Anatolia, the southern Caucasus, Persia, Afghanistan, Baluchistan, and Kashmir. To this list should be added Bokhara and other parts of Turkestan, the vast region just north of Persia and Afghanistan. However, this plant has been cultivated in China since a very early date and further investigations may modify our notions somewhat as to its oriental distribution.

According to De Candolle the Romans brought lucern from Media four hundred and seventy years before the Christian era; hence the generic name, *Medicago*. The plant is mentioned by early Roman writers.

It is difficult to determine whether lucern is really indigenous to North Africa, but it is certain that it has been cultivated from a very early date and found its way to Spain centuries ago, perhaps at the time of the Moorish invasion, and was afterwards brought by the Spaniards to South America, and later to California. Some of it probably came over direct from Europe to America. In the light of the new theory of mutation we must regard this species as a collection of elementary species differing widely in character, some of which have been isolated under cultivation, but in none of them do we find the plant we desire for regions with extremely severe winter cold, especially with no snow on the ground.

The researches of Russian botanists show that *Medicago sativa* grows spontaneously in northern Korea, southern Manchuria and Mongolia, northern China, and all of Turkestan. Further research may serve to give more credit to the Chinese in developing *Medicago sativa* than we do now. One claim is that alfalfa followed the ancient southern caravan tracks westward many centuries ago. Certain it is that the plant was cultivated in Turkestan from very ancient times.

^a Watt, George. Dictionary of the Economic Products of India. 1892.

The writer returned home from Siberia and Turkestan in January, 1909, via Trans-Caucasia, the Black Sea, and the Mediterranean Sea. He took occasion to visit the Sahara Desert in northern Africa to study the alfalfa as cultivated by the Arabs. In asking an Arab at Biskra if the alfalfa he grew was not secured by him from the French, it was amusing to note his eagerness to insist that on the contrary the French had obtained it from the Arabs. Alfalfa is one of the favorite plants of the oases, where it has been grown from time immemorial.

The point to which particular attention is directed is that so far no pure strain of *Medicago sativa* has appeared which is sufficiently hardy for the northern tier of States in the Prairie Northwest—that is, none that has not suffered at times from winterkilling. In other words, we have been endeavoring to cultivate common alfalfa far north of its ancient limits, and the process is fairly successful in regions of abundant snowfall, as the snow serves as a perfect winter protection. But there is a large area in the Prairie Northwest where the most severe cold comes occasionally with no snow on the ground. An example of this was in February, 1899, when millions of dollars' worth of common alfalfa was lost from our northern boundary south to Kansas.

The writer's ideal is an alfalfa that will never winterkill under the most severe conditions that can be found in the Prairie Northwest.

Medicago sativa turkestanica.—Probably the hardest form of *Medicago sativa* is the one introduced from Turkestan in 1898. This proved more resistant to drought and cold than the ordinary alfalfa in cultivation in the United States. In his second trip to Turkestan in 1908, after a lapse of eleven years, the writer was interested in learning of the remarkable growth of the export of Turkestan alfalfa seed. On good authority he learned that 200,000 poods^a go out of the khanate of Khiva alone, and perhaps upwards of 100,000 poods from the remaining sections of Turkestan. This may be explained by the multitude of camels in Turkestan which eat the old dry stems after the plants have been left standing for seed. The larger part of this seed goes to South America, where the area to which the plant is adapted is larger than that in the United States.

A danger now confronts the industry, owing to the fact that the seed passes through the hands of so many middlemen and a certain amount of seed is shipped from southern Persia by the Caspian Sea which also goes into the market under the same name. Efforts are being made to correct this, as seed of the far southern region can scarcely be expected to be as cold resistant as the more northern types.

^a A Russian pood equals 32 pounds.

The name "turkestanica" is not a botanical name, but one given by Russian agronomists to distinguish the alfalfa found in Russian Turkestan and central Asia. S. P. I. No. 20711, from Prof. V. R. Williams, at Moscow, was originally from a single plant found at Tashkend, the capital of Russian Turkestan. At Moscow, Professor Williams has found this strain very hardy, very productive, and a beautiful plant, while the French lucern, by which is meant the ordinary cultivated alfalfa of Europe and North Africa, is winter-killed.

MEDICAGO MEDIA.

Sand lucern.—Lucern is only another name for alfalfa and is the one most commonly used in Europe. Sand lucern (*Medicago media* Persoon) is usually regarded as a natural hybrid of *Medicago falcata* and *M. sativa*. The flowers of sand lucern vary from pale yellow to green and violet. It appears that where the two species overlap in Europe and Asia natural hybrids occur, although not abundantly, and the hybrid ranges farther north than *Medicago sativa*. This hybrid origin makes our work with the ordinary sand lucern uncertain, as we do not know the exact origin of the two parents. Some of the strains of common alfalfa now in cultivation appear to be pure types of this species, and whether they are not really hybrid mixtures with *Medicago falcata* remains to be determined. This problem is now in the process of investigation by the Department of Agriculture.

In the light of the previous discussion of the varying hardness of a species of a plant extending over a wide area it is reasonable to suppose that the native sand lucern of northern Sweden, western Siberia, and the Volga River region of eastern Russia would not be of the same degree of hardness as the native sand lucern of Hungary and other parts of southern Europe. A very interesting field for further work is opened up for plant breeders by the importation of these new types of wild and cultivated alfalfas from various places in Europe and Asia.

It would be of great interest to make the cross referred to artificially in order to see whether nature's work can be reproduced. Experiments should also be made in crossing strains of definitely known origin of these two species of alfalfa to determine the best combination. In other words, nature has pointed the way by giving us a good hybrid alfalfa, but it may not be the best one that it is possible to make.

Sand lucern in Russia.—In 1897 the writer learned of the existence of sand lucern in Russia in his tour of the Volga River region. It is native in this region of eastern Russia. It is found at least as far north as Perm Province and is called "sand lucern" by the peasants.

In 1907 seed descended from a single plant grown in Voronezh Province of the lower Volga River region was obtained. This spontaneous or natural hybrid will sometimes have yellow flowers on one branch and blue flowers on another, or both on one branch. As already stated, sand lucern is considered to be a natural hybrid of *Medicago sativa* and *Medicago falcata* (S. P. I. No. 20714). S. P. I. No. 20715 is from the same region, but bears yellow flowers and is in fact almost *Medicago falcata* in its characteristics. S. P. I. No. 20716, from the same region, is a plant of vigorous growth, very hardy and productive, with black-green flowers. These three lots of seed were selected by Professor Williams, of the Agricultural College at Moscow.

In 1906 the writer secured seed of sand lucern from north Sweden, 60° north latitude (S. P. I. No. 20571). The plant appears to be in cultivation more in Hungary than elsewhere in Europe.

Herbarium specimens from lower Austria at the Imperial Botanic Garden in St. Petersburg were marked as growing spontaneously among the parent species, *Medicago sativa* and *M. falcata*, and there were also specimens from the rocks on the eastern shore of the Caspian Sea.

MEDICAGO GLUTINOSA.

Medicago glutinosa Bieberstein is a native of the Caucasus Mountains and Trans-Caucasia generally, especially of Armenia, where it is found up to a height of 7,500 feet. It is the only one of the 21 species of *Medicago* native of Caucasia which the writer thought worthy of introduction. His intention was to secure seed when returning through the Caucasus from Turkestan, but it was too late in the season and there was too much snow in the mountains to make this feasible. When it is obtained, it should be from the very dry upland region surrounding Mount Ararat in Armenia, the mountain mentioned in the eighth chapter of Genesis.

This plant is closely related to the *Medicago falcata* of western Siberia, the main distinction being the minute glutinous hairs found on the seed pods and young shoots.

MEDICAGO ARBOREA.

Medicago arborea L. is the largest representative of the *Medicago* genus, attaining a height of upwards of 10 feet. It is a native of the Mediterranean region of Europe, Asia, and North Africa, and is the "cytisus" mentioned by ancient Greek and Roman writers as an excellent forage plant. It is especially common on the islands of the Greek archipelago and in southern Italy. It is cultivated to a limited

extent in various portions of its range, but as it gets woody too quickly and is less productive, the ordinary lucern is much more in favor. It is a favorite wild plant, as it furnishes rich feed for cattle, sheep, and goats. In old plants the wood is dark and hard like ebony, and its use for saber handles, canes, and beads is recorded.

The writer's personal observations in gathering wild seeds of this plant are confined to Mount Lycabatos at Athens, near Mars Hill, on which the Apostle Paul preached to the Athenians, and to the cliffs near the outskirts of Naples, Italy, where the plants were found growing in the crevices of rocks, where they were inaccessible to any live stock. The plants seemed to flourish in the driest possible crevices in almost perpendicular cliffs where, apparently, no water could get to them.

Medicago arborea appears of value in hot, dry places where few other plants will live, but its greatest value is perhaps to be looked for from the standpoint of breeding. Some of its remarkable vigor of growth could with advantage be imparted to the other *Medicagos* of more northern origin. This species has been tried in a limited way in southern California as an ornamental plant, and north of its main range in Europe is considered only as an ornamental shrub needing winter protection. The large, bright yellow flowers are abundantly produced.

THE FUTURE ALFALFA FOR AMERICA.

From a personal study of the alfalfas on four continents as outlined in the foregoing pages, the thought has come very strongly to the writer that no one alfalfa has all the good points needed for our future agriculture. All of them, in the light of the mutation theory, are collections of elementary species varying widely in important characteristics.

This opens a vast field for the plant breeder. The elementary species which are the best for each particular region may be isolated by selection. Parallel with this line of experimentation should be carried on experiments in hybridization.

In the spring of 1908 the writer began this work independently in South Dakota by potting plants of several alfalfas obtained in his former tours to Asia, with a view to hybridization. However, the idea is not wholly new, experiments having been started independently by the Department of Agriculture. Nature has already pointed out the way in the natural hybrid known as *Medicago media*, or sand lucern. There are many combinations possible, and it is a promising field for the plant breeder, especially since Mendel's law of heredity has given us a quick method of breeding hybrids true to seed. This, however, is a work for the plant breeder and not for the farmer. The

Siberian alfalfas, in their present unselected state, fresh from the wilds of Siberia, will, it is hoped, prove useful in solving the alfalfa problem in the Prairie Northwest.

NOTES ON THE CLOVERS OF EASTERN EUROPEAN RUSSIA AND SIBERIA.

There are more than 250 species of *Trifolium* in the temperate and subtropical regions of the Old World and North America; also in the mountains of tropical Africa and South America.

TRIFOLIUM PRATENSE—RED CLOVER.

The ordinary red clover (*Trifolium pratense* L.) is a native of Europe, North Africa, and northern and middle Asia. As cultivated in the United States it is quite a hairy plant, while smooth-leaved forms have been found in parts of Europe, especially in Norway and eastern Russia. The American red clover seed sometimes comes to Russia, owing to its cheapness, but is objected to by the Russian planters owing to the hairiness of the leaves, causing dusty hay and heaves in horses.

The smooth-leaved clover of the Volga River region of eastern Russia is now being tested in the United States as Orel clover under the direction of the Department of Agriculture. The form most in favor for the colder regions of European Russia is that from the Province of Perm, known as the Perm clover. It is perennial, living several years at least. This may turn out to be much the same strain as the Orel clover.

In Siberia red clover is found native over a wide area in the steppe region of western Siberia and south to the Altai Mountains and Turkestan and westward to the Trans-Baikal region. It is common in the south part of Tomsk Province, where seed was collected by the writer in 1908.

The white clover (*Trifolium repens*) is very widely distributed in Siberia and southward at least to the Mongolian and Pamir plateaus, as well as in Europe, North Africa, North America, and sub-Arctic America. A giant form from the upland meadows of north Italy is interesting. It is known as *Trifolium bianco lodigensis*. The writer found that it was being tested as a novelty at Moscow, Russia, in 1906, and that a form with dark red spotted leaves was being isolated.

PERM RED CLOVER.

In 1908 at the Agricultural College in Moscow the writer saw large fields of the Perm red clover, three or four years from the seed without resowing, all of luxuriant growth and showing the great vigor of

the plant. The Russian Government has been promoting the spread of this Perm red clover over other parts of Russia. At Moscow the comparative yields were as follows: Seed from southern Sweden, 4; seed from Orel, Russia, 12; seed from Perm, north of Orel, 18. As the Province of Perm is farther north than Orel, these yields in the severe climate of Moscow are suggestive and indicate that the plant is worthy of trial in the United States. The general low esteem in which American red clover is held in Russia indicates the need of improving the plant now in our cultivation. The main objection to our American clover, aside from its lesser hardiness, is its abundant hairiness and consequent dusty hay.

TRIFOLIUM MEDIUM.

In the Volga River region of eastern Russia great interest has been aroused in recent years in the native red clover of the dry steppes. This is especially the case since the frequent droughts of recent years. The form known as *Trifolium alpestre* Crantz, which according to other authorities is *Trifolium medium*. L., has attracted especial attention owing to its deeper growing taproots.

The wild red clover is found all over Russia from the far north to the extreme south and from east to west. Russian authorities state that there are two varieties of this clover. The first has round leaves with a white spot; the second, with longer leaves, more pubescent than the first, of one color throughout, without the spot. The flower head of the second variety is longer than that of the first. The second variety deserves the first consideration, since it is more resistant to cold and drought. The characteristic that gives it very great value for dry regions is the very strong root system, consisting of deep-growing taproots with numerous laterals. These plants are found in complete possession of the dry steppes. The cultivation of this native dry-land clover as found in the dry regions of extreme eastern Russia is specially recommended by the Russian authorities, this variety being immensely superior to the red clover of western Europe, which extended tests show to be very decidedly lacking in hardiness.

The existence of the deep-growing taproots of this wild red clover was first discovered in 1903 in the Province of Samara, and experiments were begun in 1904. The great famine of eastern Russia, to alleviate which America rendered valuable aid, greatly stimulated the efforts of the Russian Government to find a plant and to determine methods of cultivation better adapted to this vast steppe region. The seed of this wild, taprooted clover ripens in the central part of the Province of Samara in the second half of July, but in old fields the seed ripens earlier than in those of more recent date.

Cattle are very fond of this wild clover, so much so that the plants do not have much of a chance where the range is overstocked.

TRIFOLIUM MONTANUM.

Trifolium montanum is a drought-resistant clover with white flowers found in the southeastern provinces of European Russia, such as Kharkof (S. P. I. No. 20655), Voronezh (S. P. I. No. 20656), and Saratov (S. P. I. No. 20660). The species does not appear to extend far into Siberia, botanical literature giving it as being rare in Omsk and Tomsk and as native of the southern part of the Province of Tobolsk, western Siberia. In the Volga River province it does not appear to be a heavy cropper, but is very drought resistant. There is room for more study of the affinities of the European and western Siberian red clovers and close allies.

TRIFOLIUM LUPINASTER.

Trifolium lupinaster L. may be termed the dominant representative of the clover genus in Siberia. It is very widely distributed, practically throughout the length and breadth of Siberia, extending farther north than any other type of the Trifoliums, and into Mongolia and Turkestan. Its northern range is in the vicinity of the Arctic Circle across Siberia. Specimens have been collected in the Province of Archangel, near the Arctic Circle in European Russia. It is an extremely abundant plant on the open steppes and is found along with the three species of Siberian alfalfa already mentioned. It is a perennial with a strong root system. The judgment of the writer is that it will not compete with the ordinary clover where that is perfectly hardy, but it is worthy of trial in our most northern and driest regions, owing to its perfect hardiness and capacity for resisting drought. It is very common in the wild hay offered on Siberian markets, and may be found to hold its own as a wild plant to introduce into our pastures.

The plant consists mainly of a single stem with few branches, with a cluster of large, rose-colored flowers at the top. The color varies, however, to light violet and even white. In the steppe regions of western Siberia, as elsewhere, it is a common practice for the peasants after they have raised a number of crops of wheat to abandon the field for several years. The weeds that come in at first are crowded out by the ordinary grasses, and along with them this clover holds its own and seeds freely, showing great vigor under unfavorable circumstances.

"Lupinaster" means "similar to the lupine," referring to the five leaflets similar to the lupine. Perhaps "Siberian lupine clover" will

be a good name for the plant in case it should be found suitable for growing on our northern borders. In the Province of Tomsk it has been found on alkali soils. At Moscow the suggestion was made that it may be necessary to scratch the seed of this clover before planting to insure even germination, as it is now well understood that this is necessary for a number of legumes to secure the best results in germination. European seedsmen now have machines for scratching leguminous seeds.

TRIFOLIUM SUAVEOLENS—PERSIAN CLOVER.

Trifolium suaveolens Willd. is native in southern Europe, North Africa to Persia, and in Afghanistan and India. In his trip to Russia and Turkestan in 1908 the writer heard of the Persian clover Schabdar, which was being introduced under government auspices into Turkestan from northeastern Persia as a valuable annual clover for rotation in the cotton-growing region. Previous to this time the Department of Agriculture had received from India seed^a of two local varieties of the shaftal clover, which is considered one of the best forage plants in India and botanically appears to be a cultivated form of this species. In the course of the summer it was also learned that this Persian clover Schabdar belonged to this species, and it seemed advisable to obtain as much seed as possible from northeastern Persia, this being the most northeastern point where it was in cultivation.

This is a plant of extremely vigorous growth, but is sensitive to night frosts and needs hot summers for its best development. In Persia and Afghanistan usually the third growth is left standing for seed. Farther north, in Turkestan, the limit of the strain on the north border of the cotton belt, experience shows that it is better to cut it only once for fodder and to leave the second growth for seed.

The botanical name of this plant, *Trifolium suaveolens*, means "sweet scented." The flowers are small and sweet. They contain a large quantity of honey and are a great favorite with the bees. The lateness of the season made it impracticable to go to Meshed, the capital of northeastern Persia, near the meeting point of Afghanistan, Turkestan, and Persia. Enough seed originally from Meshed and grown one year in Turkestan was obtained, however, at Tashkend and the Hunger Steppe, Turkestan, for a good trial. Since arriving home a shipment of nearly six hundred pounds has been received direct

^a This seed (S. P. I. Nos. 19506 and 19507) was presented to the Department of Agriculture by Mr. Philip Parker, experimental officer in the irrigation service of India, through Mr. Charles J. Brand, of the Bureau of Plant Industry, in December, 1906.

from Meshed. It appears probable that this plant will be found valuable in the regions of the most extreme heat in the Southwest. Plenty of bacteria nodules are formed the first year, as was found on examining the plant in the field at Tashkend.

CAN PLANTS BE ACCLIMATIZED TO ENDURE A GREATER DEGREE OF COLD?

Some of the most fundamental problems in agriculture and horticulture in the United States depend upon the right answer to this question. In view of the fact that the writer's opinion on this subject differs materially from those usually held, it appears only fair in this connection to define briefly his position, as outlined during the past few years in a number of addresses and bulletins. The discussion may be divided into (1) annual plants, or those enduring but one season, and (2) perennial plants, those living more than one year.

ACCLIMATIZATION OF ANNUAL PLANTS.

The history of cultivated annual plants has been quoted as an exception to the law that plants can not be acclimatized to a greater degree of cold. Indian corn, for example, in its native tropical and semitropical home in South America attains a height of 20 feet, requiring seven months for maturity, and has kernels several times the size of ordinary corn. The Indians before Columbus discovered America had already completed the work of carrying the plant northward on the American continent into Canada, but the plant has simply been dwarfed and shortened in its period of maturity. It still needs extreme heat for a part of the growing season, and no variety has been originated which is adapted to the cool nights of northern Europe.

The theory of mutations has thrown a new light on the subject of acclimatizing annual plants. It appears that the ordinary botanical species usually consists of a number of elementary species or distinct mutations. By the critical methods of observation of Doctor Nilsson and his associates at the experiment station at Svalof, Sweden, new varieties of cereals are being produced by isolating mutations. The Swedish Select oat imported by the United States Department of Agriculture is one of the results of this work.

This work may be described in another way by saying that elementary species are being isolated from systematic species. An ordinary variety of barley, for example, may consist of a number of elementary species or distinct mutations. These, in the course of years, have adjusted themselves in a more or less constant proportion to meet the conditions of a given locality. When the seed is now

transported to a new environment the relative proportions of these elementary species are rearranged to meet the new conditions. For example, if a variety of barley is taken northward the extra-early elementary species within the limit of the variety soon outnumber the later maturing mutations, and if taken too far north the late sorts are soon entirely eliminated. Doctor Nilsson believes that a very early variety which will be adapted to far northern conditions may be originated far south, because the early mutations will surely appear whether the variety is raised north or south, and the problem is mainly the isolation of these early mutations when they appear.

ACCLIMATIZATION OF PERENNIAL PLANTS.

It is worthy of note that the many failures in farming in the semiarid regions of the West are due to the fact that the plants cultivated are from the milder regions of central Europe, showing that it is unwise to farm in a dry, cold climate with wet, warm climate plants. This is a very fundamental proposition, but the farmers of America have spent hundreds of millions of dollars in a vain effort to acclimatize certain plants.

Let it now be placed on record that his study of horticultural problems in the Prairie Northwest during the past twenty years has taught the writer to have no faith in the possibility of acclimatizing perennial plants to a greater degree of cold than that to which they are accustomed in their original habitat. Why is it that some trees and shrubs live and others die at a temperature of -40° F. with the ground bare of snow? In the endeavor to answer this question in the study of hundreds of kinds of fruit and ornamental trees and shrubs it appears that those native to a cold climate prove hardy, while those from a milder region are winterkilled. On the other hand, it appears that the original source of the seed makes a great difference. The box elder, red cedar, and many other trees from southern seed prove short lived and tender in the north, while trees of the same species of northern origin were hardy at the north. It appears, then, that for horticultural purposes the botanical name is entirely insufficient; that there is a difference in the species that can not be defined in botanical terms.

The writer does not believe in giving plants winter protection, as that is horticulture on crutches, and hence undesirable. In his first trip to Russia in 1894 he became interested in the results of Russian experiments with seed of evergreens from the northern regions of Russia and western Siberia as compared with seed of the same species from western Europe. In each case the native Russian seed had given plants of superior hardiness. It appeared then that nature was

able to acclimatize the same species to widely different regions, but there was no means of determining the length of time which had been taken for this work. This thought came to mind in reading the following in the "Origin of Cultivated Plants," by De Candolle:

The northern limits of wild species * * * have not changed within historic times, although the seeds are carried frequently and continually to the north of each limit. Periods of more than four or five thousand years or changements of form and duration are needed apparently to produce a modification in a plant which will allow it to support a greater degree of cold.

Combining these two fundamental propositions, it seems possible to take full advantage of the great work done for us by nature in acclimatizing plants and to cultivate farther north the hardiest form of a species instead of the form adapted in the course of thousands of years to a moist climate. We should "hitch our wagon to a star," but should be careful to pick out the star that is going the right way for our purpose.

This fundamental thought, to work *with* and not *against* Nature in adapting plants to our prairie conditions, should underlie all efforts in the improvement of plants.

Concisely stated, the writer's belief is that plants can not be brought to endure any greater degree of cold to any noteworthy extent; that hardiness can not be bred into plants by selection alone. The ability to endure cold is probably a unit characteristic of the species which may be imparted by hybridizing. In fact, in his work in originating many hybrids between hardy and tender fruits at the South Dakota Agricultural Experiment Station, he has obtained hardy plants from the seed of tender varieties by hybridizing with the hardy ones, showing that the hardy male parent can transmit its hardiness even when the female parent species is tender.

The only other way in which acclimatization might possibly occur is by some great mutation or sudden change in the species, according to De Vries's theory of mutation. It appears as the result of De Vries's experiments that new varieties of plants and animals may originate as freaks or sports which are capable of reproducing true to seed. The writer has summarized this in the statement that evolution may be likened to a kangaroo rather than a snail; that changes that were formerly thought to demand thousands of years really take place suddenly. Applying this thought to the history of Shorthorn cattle, for instance, the "Champion of England," who stamped himself so indelibly upon the breed, was really a mutation and fully prepotent in his ability to transmit his perfect points.

A hardy plant may appear from tender stock, then, as a mutation, but so far, out of many instances, as in the case of the apple, rasp-

berry, grape, alfalfa, and clover, no noteworthy progress has been made in making plants hardier by selection from tender stock. It is like the never-ending work of Sisyphus.

There is much discussion as to acclimatizing alfalfa, but the occasional test winters, such as that of 1898-9, in which millions of dollars' worth of alfalfa was destroyed in the West and Northwest, indicate that it is not feasible to get hardy plants by selecting from tender stock. In each and every case it is starting on a work that may take many thousands of years for completion and the test winters may compel us to begin all over again. Nature takes a century of centuries for some experiments; let us leave such work to her. In other words, the writer has believed that those who were attempting to acclimatize the alfalfa brought over from Africa by the Spaniards and which reached California by way of the Spanish settlements in South America were starting on a ten-thousand-year job, and hence on one that they could never finish.

This is applying De Candolle's law to agricultural problems. Hence the overland journey of 2,000 miles in 1897-8 in northern Turkestan, western China, and southern Siberia, in an endeavor to find the hardiest form of the common alfalfa.

To return to Siberia in 1908, after a lapse of eleven years, and to learn that nature had done the work of breeding a hardy alfalfa was indeed a great pleasure. It is hoped that it will help in solving the alfalfa question on the North American continent. It appears as a sensible proposition for the United States, in the task of developing our natural agricultural resources, to take advantage of the work of nature through countless ages in other regions of the world. National or patriotic sentiment has no reference to plant life. We should be cosmopolitan and get as many kinds of economic plants from as many regions as possible, bring them together here, and let the fittest survive. We shall be satisfied with nothing less than the best of everything for every region. That is the fundamental thought of the agricultural exploration work which has been planned and carried out during the past twelve years by the present Secretary of Agriculture.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 151.

B. T. GALLOWAY, *Chief of Bureau.*

FRUITS RECOMMENDED BY THE AMERICAN POMOLOGICAL SOCIETY FOR CULTIVATION IN THE
VARIOUS SECTIONS OF THE UNITED
STATES AND CANADA.

REVISED BY
A COMMITTEE OF THE AMERICAN POMOLOGICAL SOCIETY,
W. H. RAGAN, CHAIRMAN.

ISSUED JUNE 26, 1909.



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POMOLOGICAL COLLECTIONS.

G. B. Brackett, *Pomologist.*
W. H. Ragan, *Expert in Pomological Nomenclature.*

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., February 26, 1909.

SIR: I have the honor to transmit herewith a manuscript entitled "Fruits Recommended by the American Pomological Society for Cultivation in the Various Sections of the United States and Canada." This catalogue has been prepared by the committee of the American Pomological Society on revision of the catalogue of fruits, of which Prof. W. H. Ragan, Expert in Pomological Nomenclature, Bureau of Plant Industry, is chairman, and has been submitted for publication by Col. G. B. Brackett, Pomologist.

The varieties of fruits included in these pages have been recommended and rated by practical growers, who have tested them in various sections of the country, and these lists can not fail to prove of value to the planter who wishes reliable information as to what fruits will probably succeed in his soil and locality.

This manuscript constitutes the third revised catalogue of fruits which has been prepared under the joint auspices of the United States Department of Agriculture and the American Pomological Society, the others having been published as bulletins 6 and 8 of the Division of Pomology, which became a part of the Bureau of Plant Industry upon its organization in 1901. The bulletins mentioned have proved of great value and several editions have been required to meet the large demand for them.

I recommend that this manuscript be published as Bulletin No. 151 of the special series of this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

PREFATORY STATEMENT.^a

The revised catalogue of fruits recommended for cultivation in the various sections of the United States and Canada, prepared under the joint auspices of the American Pomological Society and the Bureau of Plant Industry of the United States Department of Agriculture, is herewith submitted.

In making this revision the chairman of the committee has availed himself of all the practical information that could be secured concerning the behavior of varieties in the several districts into which the territory covered has been subdivided. Heretofore lists of this character have been made up largely upon the recommendation of a comparatively few experts, while the masses of practical fruit growers have been less freely consulted. In this case the expert has not been ignored, but his testimony has been strengthened by that of a large number of less known, though nevertheless worthy, fruit growers, whose locations and practical experience entitle their opinions to favorable consideration. These were reached and consulted through a series of inquiries sent out from this Office. About two thousand of these inquiries were mailed, and they brought many satisfactory answers, which, being compiled by districts, form the basis of the subjoined fruit lists; but with all this painstaking we are well aware of the fact that infallible fruit lists have never been produced. So variable are conditions that a variety which proves satisfactory in one season or in one neighborhood may prove the reverse near by or even another year with the same grower. These facts render hasty conclusions unsafe and should admonish the planter to cultivate patience in deciding upon varieties.

It will be found, also, that honest differences may exist in regard to qualities that combine in the formation of estimates we place upon a given variety. Mere excellence of the fruit itself may be the basis of one man's ratings; another may consider its commercial value as

^a It should be borne in mind that these lists are not merely the reflections of opinions having their origin with the chairman and his colleagues in the offices of the Bureau of Plant Industry, but are the deliberate ratings of practical fruit growers in the several pomological districts, obtained through extensive correspondence, each speaking for himself and from his own standpoint of experience with the variety under consideration. The correspondence referred to was conducted during the first half of the year 1908, and this compilation of results is therefore as nearly up to date as possible.

its highest quality, while yet another will carefully consider a combination of qualities, such as hardiness of tree or plant, its fruitfulness under varying conditions, etc., yet the rating of each must be given as identical in lists like these.

The general plan of this catalogue is that of its predecessors that were evolved during many years of intelligent, patient labor by men like Wilder, Downing, Thomas, Barry, and Lyon, to whom we owe debts of gratitude. In consequence of the growth and development of our country, as well as of the greater number of varieties now cultivated and the rapidly expanding industry of fruit growing, a steadily increasing list of varieties forces itself upon us. What are therefore really select lists of fruits become apparently lengthy, but in fact are not, since the varieties embraced in this catalogue actually constitute eighteen separate lists. It will be seen, however, that many varieties are only recommended "for further trial," thus indicating that they should be planted with proper caution.

As heretofore, Prof. E. J. Wickson, of the University of California, has had much to do with the preparation of the lists for the Pacific Coast States, though a large number of individual fruit growers living within that territory have been freely consulted.

Respectfully submitted:

W. H. RAGAN, *Chairman.*

OFFICE OF POMOLOGICAL COLLECTIONS,
Washington, D. C., February 19, 1909.

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FRUITS RECOMMENDED BY THE AMERICAN POMOLOGICAL SOCIETY FOR CULTIVATION IN THE VARIOUS SECTIONS OF THE UNITED STATES AND CANADA.

PLAN OF THE CATALOGUE.

This catalogue embraces species and varieties of fruits and nuts recommended for cultivation in the United States and the British North American provinces. These are arranged alphabetically in two ^a divisions, as follows:

Division 1.—Species and varieties mainly adapted to culture in the Northern and Middle States of the United States and in adjacent portions of the British provinces.

Division 2.—More southern, tropical, and subtropical species and varieties.

Varieties known to succeed in a given district are indicated by an asterisk (*); if highly successful, by two asterisks (**); if considered promising, by a dagger (†); and if not reported on, by a dotted line (....). These conclusions are not, however, to be accepted as absolutely correct and infallible, but rather as reflections of the opinions and experiences of practical fruit growers within the district. On account of the extended range of the districts and of the varying soil and climatic conditions that prevail within them, the above caution must be kept in mind in considering the recommendations made in this catalogue. No planter should attempt to follow its markings absolutely, but should rely rather largely upon the experience of others within his immediate vicinity and a correct knowledge of his own location and environment in the district.

Following the rules and recommendations of the American Pomological Society,^b prefixes, suffixes, secondary words, and apostrophic or possessive terminations, together with words whose significations are expressed in the descriptive columns, are eliminated from

^a The third division of the lists previously printed is omitted from this publication because of the lack of agreement among botanists as to the proper classifications of the different species.

^b See p. 65.

the names of varieties when not required to insure their identity. Synonyms are italicized and included within parentheses.^a Foreign names of varieties are only anglicized in the interest of brevity or for convenience of pronunciation.

The entire territory represented is divided into eighteen pomological districts, with little regard to State or provincial boundaries, but with primary reference to the influence of latitude, elevation, prevailing winds, and oceanic and lacustrine exposures upon their adaptation to pomological pursuits (see map, Pl. I).

**POMOLOGICAL DISTRICTS AS DEFINED BY THE AMERICAN
POMOLOGICAL SOCIETY.**

District No. 1.—Maine above 500 feet elevation; New Hampshire, Vermont, and New York north of latitude 44°; Ontario north of Lake Simcoe and east of longitude 80°; Quebec, New Brunswick, and Prince Edward Island. The dominant natural feature of this district is the St. Lawrence Valley. Many of the hardier fruits flourish within its borders.

District No. 2.—Nova Scotia; Maine below 500 feet elevation; New Hampshire and Vermont south of latitude 44°; Massachusetts; Rhode Island; Connecticut; New York south of latitude 44°, except Long Island; northern New Jersey above 500 feet elevation; Pennsylvania east of the Susquehanna River and above 500 feet elevation, north of latitude 41° west to the Allegheny River, and all of that portion of the State lying north of the Ohio River; Ohio and Indiana north of latitude 40°; the lower peninsula of Michigan; and Ontario south of Lake Simcoe. The Annapolis Valley of Nova Scotia, the North Atlantic coast, the lake region of western New York, Ohio, Ontario, and Michigan, and the Hudson River Valley are the leading features of District No. 2. This may be considered the northern grape, peach, and winter-apple district.

District No. 3.—Long Island; New Jersey, except a small portion north; eastern Pennsylvania below 500 feet elevation; Delaware; and Maryland and Virginia below 500 feet elevation. This is the Delaware and Chesapeake Bay district. Though a small district, its productive capacity of the fruits that succeed within its borders is great.

District No. 4.—Pennsylvania above 500 feet elevation and south of latitude 41°; Maryland, Virginia, North Carolina, South Carolina, Georgia, Mississippi, and Alabama above 500 feet elevation; West Virginia; Tennessee and Kentucky; Ohio and Indiana south of latitude 40°; southern Illinois below the general elevation of 500 feet, from the Wabash to the Mississippi; Missouri south of a line from near St. Louis and along the elevation of 1,000 feet to the southeast corner of Kansas;

^a Synonyms are used for the better identification of varieties.

Oklahoma below 2,000 feet elevation; and Arkansas north of latitude 35° , also south of it wherever the elevation exceeds 500 feet. The Allegheny and the Ozark mountains and the valleys of the Ohio, the Tennessee, and the Cumberland, and portions of the Wabash, the Mississippi, and the Arkansas rivers are embraced within this district. Portions of it are noted fruit regions, while throughout its vast territory the hardier deciduous fruits flourish. Many of the varieties recommended succeed best in certain localities within the district. An exception to the general character of the district occurs in those portions of Kentucky, Tennessee, Arkansas, and southeastern Missouri lying near the Mississippi River, where varieties adapted to culture in districts 5 and 7 generally succeed.

District No. 5.—Eastern North Carolina, South Carolina, and Georgia below 500 feet elevation; and Florida north of latitude 30° east of the Chattahoochee River and above 100 feet elevation. This district embraces the southern Atlantic seaboard, with its many frith-like indentations and valleys. The climate is generally mild, and within its borders many of the more tender deciduous fruits flourish.

District No. 6.—Florida south of latitude 30° , the remaining portions of the State with elevations below 100 feet, and those portions of Alabama, Mississippi, Louisiana, Arkansas, and Texas lying below the 100-foot contour line as it skirts the coast from Florida to the Rio Grande. This is the southern peninsula and the Gulf Coast district. The successful culture of citrus and other subtropical fruits and nuts is restricted to the peninsula portion of Florida and to the Delta of the Mississippi. Tropical species are only recommended for that portion of Florida lying south of latitude 27° , and are indicated by the letter *s* in connection with the starring.

District No. 7.—Florida west of the Chattahoochee River and above 100 feet elevation; Alabama, Mississippi, Louisiana, and Arkansas above 100 and below 500 feet elevation; and Texas south of Red River and above 100 and below 1,000 feet elevation. This may be denominated the valley district. It embraces portions of the Chattahoochee, Alabama, Pearl, Mississippi, Arkansas, Red, Sabine, Colorado, and Rio Grande valleys. The climate in the eastern and larger portion is warm and moist, in the extreme west more dry and tending toward aridity. A wide range of the more tender varieties and species is adapted to culture in the district.

District No. 8.—Illinois north of the 500-foot contour line as it crosses the State between 38° and 39° latitude; a very small portion of southwest Wisconsin; Iowa south of about latitude $42^{\circ} 30'$; the Missouri River Valley portion of southeastern South Dakota; Nebraska and Kansas below 2,000 feet elevation; and Missouri north of a line drawn from near St. Louis and along the elevation

of 1,000 feet to the southeast corner of Kansas. The Missouri and Mississippi valley sections of the district are its dominant features. The hardy deciduous fruits succeed in most portions, and commercial fruit growing is a rapidly developing industry.

District No. 9.—Wisconsin except the small southwest corner; Minnesota; upper Michigan; Iowa north of about latitude $42^{\circ} 30'$; North and South Dakota east of longitude 99° ; and Canada west of longitude 80° and east of longitude 99° . This district embraces the upper lakes, including Winnipeg, the upper Mississippi and the Red River valleys. Only the hardier fruits succeed, but fair progress has been made in recent years in developing varieties adapted to this region.

District No. 10.—Nebraska, Kansas, and Oklahoma above 2,000 feet, and Colorado below 5,000 feet elevation; also Texas above 1,000 feet and east of longitude 103° and the Pecos River. This is the central plain and foothill district. It lies on the eastern slope of the Continental Divide. There are small sections, especially in eastern Colorado and farther southward, where the apple and other hardy fruits are successfully grown.

District No. 11.—Texas west of longitude 103° and the Pecos River, and New Mexico south of latitude 35° . The Pecos and Rio Grande valleys are the characteristic features of this district. Considerable effort at growing fruit, especially of apples and the hardier vinifera grapes, is being made in many localities.

District No. 12.—New Mexico and Arizona north of latitude 35° ; Utah; and Colorado above 5,000 feet elevation. This district embraces the Continental Divide and the Great Salt Lake, and it also embraces the valley and canyon of the Colorado and the sources of the important streams south of the Missouri and Yellowstone. It affords a great diversity of soils and climatic conditions, and hence a wide range of fruit growing. The species successfully grown within the boundaries of this district range from the vinifera grapes to the hardy ironclad apples.

District No. 13.—The Dakotas west of longitude 99° ; Wyoming; Montana east of longitude 111° ; and the British provinces lying between longitude 99° and 111° . The upper Missouri and Yellowstone valleys are the distinctive features of the district. There is perhaps no section of the district in which fruit growing has reached a very high state of development. Leading causes of this condition may be found in the comparatively undeveloped or unsettled state of the country and its great elevation.

District No. 14.—British America west of longitude 111° and east of longitude 122° ; Montana west of longitude 111° ; Idaho; Nevada; and Washington, Oregon, and California east of the general coast

contour line of 1,000 feet elevation, commencing at the British boundary near longitude 122° and southward on said elevation to its intersection with the Southern Pacific Railway in the upper Willamette Valley, thence along the line of said railway to the Sacramento Valley, thence east and south on the eastern rim of said valley and that of the San Joaquin at an elevation of 1,000 feet to latitude 35° , thence east on said latitude to the Colorado River. The characteristic features of this district are the upper Columbia Valley and the Sierra Nevada Mountains. An exception to the general recommendation will appear in certain portions of Snake River Valley, where the vinifera grapes and other tender fruits succeed.^a

District No. 15.—The coast section of British America west of longitude 122° and of Washington, Oregon, and California north of about latitude $39^{\circ} 30'$, and bounded on the east by districts 15 and 17. This district embraces the highly developed fruit-growing sections on Puget Sound and the lower Columbia and the Willamette rivers.^b

District No. 16.—The Sacramento and San Joaquin valleys, bounded on the east by District No. 15 and on the west by the western rim of this great interior basin. The diversified fruit and nut products of this district are marvelous. There are localities in which the semitropical species and other places where the apple, pear, and other hardy fruits and nuts are grown to the highest perfection.^b

District No. 17.—The coast section of California lying between latitude 35° and about $39^{\circ} 30'$ and bounded on the east by District No. 17. Its characteristic features are the Coast Range of mountains, the Russian River, and the Sonoma, the Santa Clara, and the Pajaro valleys.^b

District No. 18.—California and Arizona south of latitude 35° . The dominant characteristics are the valleys of the Gila, the Colorado, the San Gabriel, and the Santa Ana, and the Sierra Madre Mountains. It includes the celebrated fruit districts of Santa Ana, Riverside, Santa Barbara, the Salt River Valley, San Diego, and many others.^b

^a Recent developments of the fruit industry in several isolated localities in District No. 14 have demonstrated the fact that many of the deciduous fruits can be grown with perfect success. This is especially the case in the Hood River and Rogue River valleys in Oregon, in the Wenache and Yakima valleys in Washington, and in other favored sections.

^b Districts 15, 16, 17, and 18 are peculiarly adapted to fruit and nut culture. Perhaps no portion of the earth's surface is more highly favored in climate and soil and affords a wider range of crop products than that lying within the boundaries of these four districts. The commercial value of the fruit and nut products of this section is recognized the world over.

FRUITS RECOMMENDED FOR CULTIVATION IN THE UNITED STATES AND CANADA.

Division I.—FRUITS MAINLY ADAPTED TO NORTHERN LOCALITIES.

This division includes such cultivated species, commonly designated "hardy" fruits and nuts, as have developed distinct varieties which are propagated on a commercial scale by some of the various methods of bud propagation.

Section 1.—APPLES (*Malus*).

[KEY.—Abbreviations used in the descriptions of varieties. *Origin*: Amer., America; Eur., Europe; For., France; N. Y., New York; Ont., Ontario, etc. *Form*: c, conical; o, ovate; ob, oblate; obl, oblong; r, round. *Size*: l, large; m, medium; s, small; v, very. *Color*: b, bluish; c, crimson; d, dark; g, green; p, pale; r, red; ru, russet; s, striped; w, white; y, yellow. *Flavor*: a, acid; b, brisk; m, mild; p, pleasant; r, rich; s, sweet; sa, subacid; v, very; vi, vinous. *Quality*: b, best; g, good; p, poor; v, very. *Use*: c, cider; d, dessert; k, kitchen; m, market. *Season*: e, early; l, late; in, medium; v, very.]

SUBSECTION 1.—APPLES.

Name.	Description.				Recommendations for the several districts.																					
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Akin (Akin Red).	Ill.	c	ml	yr	sa	vg	dm	l	**	†	*	†				*	†		*							
Alexander (Emperor Alexander).	Rus.	re	vl	gyrs	a	g	km	m																		
Allen (Choice).	Pa.	ob	m	yr	sa	g	dm	m								*	*		*					*		
Anisim (Anisimovka).	Rus.	re	m	yr	sa	g	dm	m								*	*		*					*		
Antonovka (Anthony's Apple).	Rus.	oblc	l	yr	sa	p	km	m	*	*	*					*	*		*					*		
Arctic.	N. Y.	re	l	yr	msa	vg	km	l	*	*	*				*	*		*					*		*	
Arkansas.	Ark.	oblc	ml	dr	sa	vg	km	l			*	**			*	*		*	*			*	*	*	*	*
Arkansas Black.	Ark.	re	ml	dr	sa	vg	km	l			*	*			*	*		*	*			*	*	*	*	*
Arnold (Arnold Beauty).	Ont.	ob	m	ey	s	vg	d	vl	*	*	*	*			*	*		*	*			*	*	*	*	*
Autumn Bough (Autumn Sweet Bough).	Amer.	re	m	y	s	vg	d	me	*	*	*	*			*	*		*	*			*	*	*	*	*
Autumn Sweet (Autumn Secret Sweet).	(?)	rob	m	y	s	vg	k	m	*	*	*	*			*	*		*	*			*	*	*	*	*
Baldwin Sweet (Baldwin Sweet).	N. Y.	rob	l	ys	ys	vg	dm	m	*	*	*	*			*	*		*	*			*	*	*	*	*
Baldwin (Red Baldwin).	Mass.	re	m	gyrs	sa	vg	dkm	l	*	*	*	*			*	*		*	*			*	*	*	*	*
Baltimore (Baltimore Pippin).	(?)	re	m	gyrs	sa	vg	dkm	l	*	*	*	*			*	*		*	*			*	*	*	*	*
Banana (Winter Banana).	Ind.	ob	m	yb	msa	vg	d	l	†	†	†	†			†	†		†	†			†	†	†	†	†
Baxter (Baxter's Red).	Ont.	re	vl	ys	ma	g	d	l	†	†	†	†			†	†		†	†			†	†	†	†	†
Beach (Apple of Commerce).	Ark.	rob	ml	gyrs	sa	vg	dm	vl	*	*	*	*			*	*		*	*			*	*	*	*	*
Belmont (Galt, Warren).	Pa.?	rob	ml	y	msa	vg	d	ml	*	*	*	*			*	*		*	*			*	*	*	*	*

[illegible]

Section 1.—Apples—Continued.

SUBSECTION 1.—APPLES—Continued.

Name.	Description.					Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lankford (Lankford's Seedling).	Del.?	robl	ml	pyb	sa	g	l	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lansingburg (Rock Pippin).	N. Y.	rob	m	wrs	msa	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Late Strawberry (Autumn Strawberry).	N. Y.	rc	l	dr	msa	g	l	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lawver (Delaware Red Winter).	(?)	rob	v l	yg	sa	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lehigh (Lehigh Greening).	Pa.	rob	v l	yg	sa	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lilly (Lilly of Kent).	Del.	rob	m	gyr	a	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Linbertwig (Red Linbertwig).	N. C.?	rob	m	gyr	a	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lirland Raspberry (Lirland Raspberry).	Rus.	obc	m	yfb	msa	vg	dm	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lorahfield (Good Pensive).	Rus.	rob	ml	yfb	sa	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Louise (Princess Louise).	Ont.	rc	ml	y	ba	g	d	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lowell (Greasy Pippin).	Amer	rob	ml	y	ba	g	g	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Loy (Loy's Seedling).	Mo.	ob	l	yrs	sa	g	m	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lubsk Reinet (Lubsk Queen).	Rus.	rc	ml	wb	a	g	a	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
McAfee (McAfee's Nonouch).	Ky.	rob	l	ygrsc	msa	g	g	dm	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
McCuller (McCuller's Winter).	N. C.	rob	m	ygrsc	msa	vg	dm	ml	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
McClintock (McClintock Red).	Ont.	rob	ml	yrs	sa	vg	dmk	ml	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
McLellan (McLellan).	Conn.	rob	ml	yrs	sa	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
McMahon (McMahon's White).	Wis.	rob	l	yw	sa	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Magnate (Magnate's No. 1).	Kans.	rc	ml	yr	sa	g	km	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Magoc (Magoc Red Strake).	Vt.	rob	m	yrs	sa	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Maiden Blush (Maiden's Blush).	N. J.	rob	m	pyb	sa	g	g	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mallinda (McLinda).	Vt.	rc	ml	yr	sa	g	dkm	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mangum (Mangum Bonum).	Ala.	obc	m	yr	sa	g	dkm	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Maud (Dile).	Ala.	obc	m	yr	sa	g	dkm	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Margaret (Early Red Margaret).	N. Y.	rob	ml	gyr	sa	g	d	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Marshall Red (Red Bellflower).	Eng.	roc	ms	gyr	sa	g	dm	e	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Norton's Melon).	Cal.	rob	l	pyrs	sa	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	N. Y.	rob	ml	pyrs	rsa	vgb	dkm	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Rus.	rob	l	rs	sa	vg	dkm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	South.	rc	ms	grsru	pa	g	dkm	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	N. H.	obc	l	rs	sa	g	dkm	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	W. Va.	rob	l	yrs	sa	g	km	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Mass.	obc	ml	gyrs	sa	g	km	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Pa.?	rob	m	gyrs	sa	g	mk	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Mont.	rob	ml	wyrs	bsa	g	km	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Mo.	c	l	pyb	bsa	vg	dkm	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	Cal.	obc	l	pyb	bsa	vgb	dk	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Melrose (Melrose).	N. J.	obc	l	pyb	bsa	vgb	dk	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[illegible]

Section 1.—Apples—Continued.

SUBSECTION 1.—APPLES—Continued.

Name.	Description.					Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	't'se.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Rutledge.....	Tex.	rob	l	rs	s	vg	dkm	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Saint Johnshury.....	Vt.	rob	m	yrs	s	vg	dkm	m	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Saint Lawrence (Montreal).....	Can. ?	obc	m	yrs	sa	vg	dkm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Salome.....	Vt.	obc	m	yrs	sa	vg	dkm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Scott Winter (Scott's Winter).....	Ill.	rc	m	wsc	a	g	mk	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Shiawassee (Michigan Beauty).....	Mich.	rob	m	wsc	bsa	g	dkm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Shuckley (Dirie Horse Bud).....	Ga.	rc	ms	pyrl	rnsa	vg	dk	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Skinner (Santa Clara King).....	Cal.	obc	l	rs	pnsa	g	dkm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Smith Cider (Smith's Cider).....	Pa.	rob	l	yrs	psa	g	km	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Smokehouse (Red Vandriere).....	Eur.	r	m	yrs	psa	g	d	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sops of Wine (Sops in Wine).....	Ohio.	rc	m	yrs	misa	g	km	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Stark (Robinson, I call).....	Me.	obc	m	yrs	psa	g	km	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Starry.....	N. J.	rob	l	yrs	psa	g	k	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Stayman Winosap (Stayman).....	Kans.	obc	m	yrs	rna	vg	dkm	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Stephenson (Stephenson's Winter).....	Mass.	rob	m	yrs	psa	g	dkm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sterling (American Beauty).....	Mass.	rc	l	yrs	rsa	vg	dm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Stone.....	Mich.	rc	l	rs	s	g	dm	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Extra.....	Ky.	rob	l	yrs	sa	vg	dkm	e	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Hagloe (Hagloe).....	Ob.	ob	m	yrs	sa	vg	dkm	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer King (Summer Chice).....	(?)	rob	m	yrs	bsa	vg	dkm	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Pearmain (Am.) (American Summer Pearmain).....	N. C. ?	rob	m	yrs	bsa	vg	dkm	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Queen (Early Queen).....	Amer.	rob	m	yrs	rpna	vg	d	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Queen (Early Queen).....	N. J. ?	rc	l	yrs	ra	vg	km	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Summer Rose (Woodman's Early).....	N. J.	rob	ms	yrs	sa	vg	dkm	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Mass.	rob	l	pyrsc	sa	vg	dkm	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	N. Y.	rob	l	gy	rsa	vg	dkm	ml	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	N. Y.	rob	s	yru	sa	vg	dk	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	N. Y.	rob	l	rc	rs	gvg	dk	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Pa.	obc	m	y	sa	vg	dkm	ml	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Rus.	obc	l	gyrs	a	g	dm	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Ala. ?	obc	l	yrs	sa	vg	dkm	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Ga.	rob	s	yrs	bsa	vg	dkm	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Rus.	rob	ms	yrs	a	g	km	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	(?)	l	rs	sa	g	km	me	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sutton (Sulton's Beauty).....	Texas Red	obobl	l	rs	sa	g	km	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tlovka (Titus Apple).....	Rus.	obobl	l	rs	sa	g	km	me	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tolman (Tolman Street).....	R. I.	obc	l	wyb	s	vg	dk	vl	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Tompson King (King of Tompkins County).....	N. Y. ?	obc	l	yrs	sa	vg	dkm	l	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[illegible]

Section 1.—Apples—Continued.

SUBSECTION 2.—CRABS.^a

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alaska (Kenyon).....	Iowa.	r	l	y	sa	g		l	*																	
Bull (Ball's Winter).....	Vt.	r	l	wy	s	g	dk	vl		†																
Brier (Brier's Sweet).....	W. Is.	re	ml	rs	s	vg	ke													†						
Dartmouth.....	N. H.		ml	y		vg	dk			*										†						
Elgin (Geneva, Lady Elgin).....	Ill.	rob	l	wyrb	sa	vg	dk	vl		*										†						
Excelstor.....	Minn.	r	ml	rs	s	vg	d	m		*										*						
Florence.....	Minn.	ob	ml	rs	a	vg	k	m		*										*						
Gibb (Gibb's Golden).....	Wis.	rob	vl	y	sa	vg	k	e		*										*						
Grant (General Grant).....	Minn.	rob	l	rs	sa	g	kc	l		*										*						
Hyslop (Hyslop's).....		re	l	dr	sa	vg	dkm	m		*										*						
Island Gem.....	Vt.	r	ml	r	sa	vg	dk	m		*										*						
Jumbo.....	Vt.	obl	vl	yr	sa	vg	dkm	l		*										*						
Lyman (Lyman's Prolific).....	Minn.	re	l	yrs	sa	g	dm	m		*										*						
Marengo (Marengo Winter).....	Ill.	rob	l	yrb	sa	g	dkc	vl		*										*						
Martha.....	Minn.	ob	ml	y	sa	vg	dkc			*										*						
Minnesota (Minnesota Prince).....	Amer.	obl	ml	y	sa	vg	km	l		*										*						
Montreal (Montreal Beauty).....	Amer.	obl	l	yrs	sa	g	k	ml		*										*						
Orange.....		rob	m	y	sa	g	k	l		*										†						
Powers (Powers's Large Red).....	N. Y.	rob	m	wyrs	a	vg	dkm	m		*										†						
Pringle (Pringle Sweet).....	Can.	rob	m	r	sa	g	km	l		*										†						
Queen (Queen Choice).....		rob	m	r	sa	g	km	m		*										†						
Red (Red Siberian).....	Eur.	rob	ml	yr	sa	g	km	m		*										†						
Shields.....	Wis.		l	rs	a	vg	o			*										†						
Southern Crab.....	Mo.	ob	l	gy	sa	a	vgb	l		*										†						
Stanstead (Rose of Stanstead).....	Can.	obl	ml	r	sa	vg	dk	e		*										*						
Sweet Russet (Summer Sweet Russet).....	Wis.		vl	ru	sa	vg	km	m		*										*						
Transcendent.....	Amer.	obl	ml	gyb	sa	g	km	m		*										*						
Van Wyck (Van Wyck's Sweet).....	N. Y.	re	l	wb	s	g	km	m		*										†						
Virginia.....		ob	m	sa	sa	g	km	m		*										*						
Whitney (Whitney's No. 20).....	Ill.	re	l	yrs	sa	g	km	m		*										*						
Yellow Siberian (Amber).....	Eur.	r	s	y	s	g	k	k		*										*						

^b This is a native American wild crab.^a Includes such possible hybrids as strongly manifest crab parentage.

Section 2.—APRICOTS (*Prunus*).

[KEY.—Origin: Afr., Africa; Amer., America; Eur., Europe; Fr., France; N. Y., New York, etc. Form: c, compressed; co, conical; ob, oblate; obl, oblong; r, round. Size: l, large; m, medium; s, small; v, very. Color: b, blushed; c, crimson; o, orange; r, red; w, white; y, yellow. Adhesion: c, cling; f, free; sc, semicling. Quality: b, best; g, good; p, poor; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium; v, very.]

Name.	Description.					Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acme (<i>Chinese, Shenae</i>)		f	m	ow	f	ggg	dgm	e																		
Alexander (<i>Russian No. 2</i>)	Rus.	obl	m	oy		g	dm	m																		
Bienheim (<i>Shirley's</i>)	Eng.	ob	m	oy		ggg	dm	m																		
Breda (<i>Ananas, De Hollande</i>)	Afr.	rob	s	o	f	vg	dm	m		*	*	*			*				*				*	*	*	
Cluster.	Tex.																									
Early Golden (<i>Dubois</i>)	N. Y.	rob	s	o	f	vg	d	e		†	†				*	†			*							
Harris (<i>Harris Hardy</i>)	N. Y.	oblco	m	orb	f	g	dm	ve																		
Hemskirk.	Eng.	robo	vl	orb	f	ggg	d	ve																		
Large Early (<i>Gros Precocet</i>)	Fr.	oblco	m	or	f	ggg	d	e																		
Moerpark (<i>De Nancy</i>)	Eng.	r	vl	or	f	ggg	d	e		*	*	*			**	*			†	†	†					
Newcastle (<i>Newcastle Early</i>)	Cal.	r	m	oy	f	gg	d	m											*	*	*			*	*	*
Orange (<i>Early Orange</i>)	Eur.	obr	m	oy	sc	g	p	e											*	*	*			*	*	*
Peach (<i>Royal Peach</i>)	Italy.	roco	vl	yo		vg	d	m		†	†				*	†			*	*	*			*	*	*
Royal (<i>Abrirot Royal</i>)	Fr.	robo	l	yor		vg	d	ve											*	*	*			*	*	*
Russian.																										
St. Ambrose.	Fr.?	rc	vl	yr		vg	d	ml		*					†	†			†	†					*	*
Sheridan.																										
Surprise.																									*	*
Tilton.	Cal.																								*	*

Section 3.—BLACKBERRIES AND DEWBERRIES (*Rubus*).

[KEY.—Origin: Amer., America; Cal., California; Ind., Indiana; Tex., Texas, etc. Form: c, conical; obl, oblong; ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: a, amber; b, black; r, red; w, white; y, yellow. Quality: b, best; g, good; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—BLACKBERRIES.

Name.	Description.				Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acme.....	Amer.	robl	l	b	bvg	dm	e	*																	
Agawam.....	Pa.	rc	l	b	vg	dm	ve		**																
Allen.....																			*	†					
Blowers.....	Wis.	ovr	m	b	g	m	m			*															
Briton (Ancient Briton).....	Amer.	obl	m	b	vgb	dm	e												**	†					
Brunton.....	Tex.	r	m	br	g	dm	e																		
Cox.....	Tex.						ve							†											
Crandall (Crandall's Early).....	Dallas.						m																		
Dallas.....	Ill.	robl	s	b	vg	dkm	m												*						
Early Harvest.....	Ohio.	obl	vl	b	vg	dkm	e												*					*	
Eldorado.....	Pa.	obl	vl	b	g	g	m			*									*					*	
Eric.....	Pa.	robl	l	b	vg	m	m			*									*				*		
Evergreen.....	Oreg.?				vg		vl																*		
Gardenia.....																									
Haupt.....															†									†	
Himalaya.....																									
Iceberg.....	Cal.	robl	l	aw	vg	d	m																		
Illinois.....																									
Kenoyer.....	Kans.																								
King (Early King).....							ve		*										*				*		
Kittatinny.....	N. J.	robl	l	b	vg	dm	ml		*										*				*		
Lawton.....	N. Y.	rov	vl	b	vg	dmk	m		*					*				*	*	*	*	*	*	*	*
Logan (Loganberry) ^a	Cal.								*									*	*	*	*	*	*	*	*
Mammoth.....	Cal.	obl	vl	b	vg	dkm	ve											*	*	*	*	*	*	*	*
Mercereau.....					g																				
Minne-waska.....	N. Y.	ov	vl	b	vg	km	em			*						*	*	*	*	*	*	*	*	*	*
Montmorency.....																									
Phenomenal.....																									
Premier.....	Cal.																								
Rathbun.....																									
Snyder.....	N. Y.	obl	l	b	g	km	ml																		
Stone (Stone's Hardy).....	Ind.	obl	ml	b	vg	dkm																			
Taylor (Taylor's Prolific).....	Wis.	robl	m	b	b	vg	d																		
Triumph (Western Triumph).....	Ind.	robl	l	b	vg	d	l			*									†	†		*	*	*	*
Triumph (Western Triumph).....	Amer.	oblov	m	b	g	d	l			*															

[illegible]

a Logan or Loganberry is a blackberry-raspberry hybrid, and is placed with blackberries for convenience.

SUBSECTION 2.—DEWBERRIES.

[illegible]

Section 4.—CHERRIES (*Prunus*).

[*K.F.Y.*—Origin: Amer. America; Eng. England; Eur. Europe; Fr. France; Ger. Germany; Ont., Ontario; Rus. Russia, etc. *Form.* c, compressed; h, heart-shaped; o, oblate; r, round. *Size.* l, large; m, medium; s, small; v, very. *Color.* a, amber; b, black; d, dark; p, purple; r, red; w, white; y, yellow. *Quality.* b, best; g, good; v, very. *Use.* d, dessert; k, kitchen; m, market. *Season.* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—HEART AND BIGARREAU CHERRIES.

Name.	Description.						Recommendations for the several districts.																		
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bing.....	Oreg.	ch	l	b	vg	dm	l		†																
Black Heart.....	Eur.?	ch	l	b	vg	dm	ve																		
Centennial.....	Cal.	oh	l	yr	vg	dm	e												†						
Chapman (California Advance).....	Cal.	h	l	yr	vg	dm	e																		
Chapland (Chapland Bigarreau).....	Ohio.	ch	ml	yr	vg	dm	e																		
Coe (Coe's Transvaal).....	Conn.	r	ml	yr	vg	dm	e																		
Dorchester (Dorchester & Latis Red).....	Mass.	rh	ml	r	vg	dm	ml																		
Eagle (Black Eagle).....	Eng.	oh	ml	b	vg	dm	ml																		
Early Purple (Early Purple Guigne).....	Eur.	rh	sm	pb	vg	dm	ve																		
Elkhorn (Black Oshart).....	(?)	h	l	b	vg	dm	l																		
Elton.....	Eng.	h	l	yr	vg	dm	e																		
Hoskins.....	Oreg.	rh	ml	yr	vg	dm	ml																		
Ida.....	Eur.	oh	l	yr	vg	dm	e																		
Knight (Knight's Early).....	Eng.	oh	l	yr	vg	dm	e																		
Lake.....	Oreg.?	oh	l	yr	vg	dm	e																		
Lambert.....	Oreg.	h	l	pr	vg	dm	ml																		
Lewelling (Black Oregon).....	Oreg.	h	l	pr	vg	dm	ml																		
Mezel (Black Bigarreau).....	Eur.	oh	l	rb	vg	dm	ml																		
Napoleon (Royal Ann).....	Eur.	h	l	yr	vg	dm	ml																		
Reynolds (Black Bigarreau).....	Eur.	oh	ml	q	vg	dm	ml																		
Rockport (Black Bigarreau).....	Oreg.	oh	l	q	vg	dm	ml																		
Rockport (Black Bigarreau).....	Ohio.	oh	l	ra	vg	dm	ml																		
Smith (Smith's Bigarreau).....	Ohio.	oh	l	ra	vg	dm	ml																		
Spanish (Black Spanish).....	Eur.	oh	l	vg	dm	dm	em																		
Tartarian (Black Tartarian).....	Rus.	h	l	yr	vg	dm	em																		
Windsor.....	Ont.	h	l	yr	vg	dm	l																		
Wood (Governor Wood).....	Ohio.	rh	ml	yr	vg	dm	em																		

Section 5.—CURREANTS (*Ribes*).

[KEY.—Origin: Amer., America; Eng., England; Eur., Europe; Fr., France; Ont., Ontario, etc. Form: ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: b, black; r, red; w, white. Quality: b, best; g, good; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium.]

SUBSECTION 1.—RIBES NIGRUM AND R. AUREUM.

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Champion (Black Champion).....	Eng.	r	vl	b	gvg	km	em	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cranchall (Cranchall's Black).....	Kans.	rov	vl	b	gvg	k	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
English (Common Black).....	Eng.	r	m	b	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Lee (Lee's Prolific).....	Amer.	r	ml	b	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Naples (Black Naples).....	Eur.	r	ml	b	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Saunder's (Saunder's Seedling Black).....	Ont.	r	ml	b	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wales (Prince of Wales).....	Ont.	r	ml	b	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

SUBSECTION 2.—RIBES RUBRUM.

Albert (Prince Albert).....	Eur.	r	l	r	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cherry Defiance.....	Eur.	r	vl	r	g	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fay (Fay's Prolific).....	N. Y.	r	vl	r	g	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Holland (Long Bunch Holland).....	Eur.	r	ms	r	g	km	em	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
London (London Market).....	Eng.	r	ms	r	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Moore Ruby (Moore's Ruby).....	N. Y.	r	vl	r	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
North Star.....	Minn.	r	m	r	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Perfection.....	Pomona.	r	m	r	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ruby Castle [Probably same as Victoria].....	N. Y.	r	ml	r	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Red Cross.....	Eur.	r	vl	r	vgb	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Red Dutch (Large Red Dutch).....	Eur.	r	ml	r	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Red Grape.....	Eur.	r	m	r	vg	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
St. Giles (Belle de St. Giles).....	Fr.	r	vl	r	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Versaillaise (La Versaillaise).....	Fr.	r	vl	r	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Victoria (May's Victoria).....	Eng.	r	ml	r	vgb	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
White Dutch (White Antwerp).....	Eur.	r	ml	w	vgb	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
White Gondoun (Gondoun White).....	Eur.	r	ml	w	vgb	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
White Grape (Imperial White).....	Eur.	r	l	w	vg	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wildcat (Wildcat Red).....	N. Y.	r	vl	r	g	m	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Section 6.—GOOSEBERRIES (*Ribes*).

[KEY.—Origin: Amer., America; Eng., England; N. Y., New York; Ont., Ontario, etc. Form: obl, oblong; ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: g, green; r, red; w, white; y, yellow. Quality: b, best; g, good; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium.]

SUBSECTION 1.—RIBES RECLINATUM (R. GROSSULARIA).^a

Name.	Description.				Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Berkeley (Duinelle).....	Eng. ^a	robl	l	gw	vqb	km	m		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chautauqua.....	N. Y.	rov	l	gy	vqb	km	m		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Columbus (Triumph).....	Amer.	rov	l	r	vq	km	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Crown Bob.....	Eng.	rov	vl	r	vq	km	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Industry (Wyndham's Industry).....	Eng.	obl	ml	g	vq	g	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Keepsake.....	Eng.	obl	lvi	gw	g	km	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wellington (Wellington's Glory).....	Eng.	ov	lvi	gw	g	km	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Whitesmith (Sir Sidney Smith).....	Eng.	ov	lvi	gw	g	km	e		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

^a Includes American seedlings of this parentage.SUBSECTION 2.—RIBES OXYACANTHOIDES.^b

	Minn. Amer.	rov	l	r	g	km	m																			
Carrie																										
Champion (Mills' Champion).....		rov	m	gy	g	km	m		*																	
Comptine.....																										
Crabhead.....																										
Downing (Downing's Seedling).....	N. Y.	r	ml	g	g	km	m		*																	
Houghton (Houghton's Seedling).....	Mass.	rov	s	gr	g	dk	m		*																	
Josselyn (Red Jacket).....	Ont.	rov	ml	r	vg	km	e		*																	
Mathews.....																										
Oregon (Oregon Champion).....	Oreg.?	obl	m	g	g	k	m		*																	
Pale Red (American Red).....	Amer	rov	s	r	vqb	dk	m		*																	
Pearl.....	Ont.	r	m	g	vqb	dk	m		*																	
Poorman.....																										
Smith (Smith's Improved).....	Vt.....	ov	m	yg	vg	dk	e		*																	

^b Includes apparent hybrids of this with other species.

Section 7.—GRAPES (*Vitis*).

[KEY.—Origin: Amer., America; Eng., England; Eur., Europe; For., Foreign; Fr., France; Ont., Ontario, etc. Form: o, oval; obl, oblong; r, round. Size: l, large; m, medium; s, small; v, very. Color: a, amber; b, black; g, green; r, red; w, white; y, yellow. Quality: b, best; g, good; p, poor; v, very. Use: d, dessert; k, kitchen; m, market; f, raisins; w, wine. Season: e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—VITIS AESTIVALIS.

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
NORTHERN GROUP.																										
Cynthiana (<i>Red River</i>).....	Ark.	r	s	b	vg	w	e		*		*	*	*	*												
Eumelan.....	N. Y.	r	m	w	vg	d	m		*		*															
Gold Coin.....	Tex.	r	ml	b	vg	dm	me							*												
Hopkins.....	Tex.	r	m	w	vg	dw	m							*												
Norton (<i>Norton's Virginia</i>).....	Va.	r	s	b	vg	w	e			*	*															
Superb.....	Ga.	r	s	b	vg	dm	ml				*	*														
Wetumka.....	Tex.	r	l	yg	g	dmw	l				†															
SOUTHERN GROUP (<i>V. Bourquiniana</i>) of Munson.																										
Delaware.....	N. J.?	r	s	r	b	dm	m	*	**	*	**	**	*	*	*	*	*	*	*	*	*	*	*	*	*	
Herbemont (<i>Warren</i>).....	South.	r	s	s	vg	dw	l				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Lenoir (<i>Jacques</i>).....	N. C.	r	s	rb	g	dm	l				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Moyer (<i>Jordan</i>).....	Can.	r	s	r	vg	dm	m	*																		
Perry.....	Tex.	r	s	yr	vg	dm	m						†	*												
Wylie (<i>Peter Wylie</i>).....	S. C.	r	s	yr	vg	d	ve							*												

SUBSECTION 2.—VITIS LABRUSCA.

Name.	Description.				Recommendations for the several districts.																			
	Origin.	Form.	Size.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NORTHERN GROUP.																								
Agawam (Roger's No. 15).....	Mass.	ro	vl	rb	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Barry (Roger's No. 43).....	Mass.	r	l	b	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Brighton.....	N.Y.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Brilliant.....	Tex.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Campbell (Campbell Early).....	Ohio.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Catawba (Red Muncy).....	N.C.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Champion (Early Champion).....	Amer.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Concord.....	Mass.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cottage.....	Mass.	r	l	r	vg	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Daisy (Daisy Early).....	Kans.	o	l	r	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[illegible]

Includes apparent hybrids.

Section 7.—*Grapes*—Continued.SUBSECTION 3.—VITIS LINSECOMII.^a

Name.	Description.				Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
America.....	Tex.	r	s	q	g	w	m							*											
Beacon.....	Tex.	r	l	q	vg	dm	e							*											
Carman.....	Tex.	r	l	q	vg	dm	vl							*	*	*									
Fern (Fern Munson).....	Tex.	r	sm	b	g	w	l							*	*	*									
Jagger (Herman Jagger).....	Tex.	r	m	b	vg	dm	m						*	*	†										
Laurel.....	Tex.	r	sm	b	vg	dm	vl							*	*	*									
Muench.....	Tex.	r	m	q	g	dm	vl							*	*	*									

^a Includes apparent hybrids.

SUBSECTION 4.—VITIS ROTUNDIFOLIA.

Eden.....	Ga.	r	l	b	vg	dw	l					*	*	*											
Flowers (Black Maxcadine).....	South.	r	l	b	g	dw	vl					*	*	*											
James.....	N. C.	r	vl	b	vg	d	vl					†	†	†											
Memory.....	South.	r	ml	br	g	m	m					*	*	*											
Mish.....	N. C.	o	l	b	g	g	ve					*	*	*											
Scuppernon.....	N. C.	r	vl	yw	g	w	m					*	*	*											
Tenderpulp.....	S. C.	r	vl	b	g	w	m					*	*	*											
Thomas.....	S. C.	r	l	b	vg	w	e					†	†	†											

SUBSECTION 5.—VITIS VINIFERA.

Alexandria (Muscat of Alexandria).....	Africa.	obl	vl	yw	vg	dr	l																		
Black Ferrara.....	For.	ro	vl	b	g	m	m																		
Black Hamburg.....	Ger.	o	vl	b	vg	d	l																		
Black Morocco.....	For.	o	ml	b	vg	d	e																		
Black Prince.....	For.	o	ml	b	vg	d	e																		
Carignane.....	Eur.	obl	vl	b	vg	d	l																		
Cornichon (Black Cornichon).....	Eur.	obl	vl	r	g	d	l																		
Empire.....	Eur.	obl	vl	r	g	d	l																		
Fiance Tolay.....	Eur.	ro	vl	r	vg	d	m																		
Gordo Bianco (Muscat).....	Spain.	r	vl	w	vg	rd	m																		

[illegible]

SUBSECTION 6.—VITIS VULPINA *syn.* RIPARIA.^a

[illegible]

Includes apparent hybrids.

Section 8.—MULBERRIES (*Morus*).

[Key.—*Origin*: Eur., Europe; N. Y., New York, etc. *Form*: c, cylindrical; l, long; s, short. *Size*: l, large; m, medium; s, small; v, very. *Color*: b, black. *Quality*: b, best; g, good; p, poor; v, very. *Use*: d, dessert; k, kitchen; m, market. *Season*: e, early; l, late; m, medium.]

Name.	Description.						Recommendations for the several districts.																		
	Orign.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abundance.	Eur.		l	b			el								†										
Black English.	N. Y.	lc	ml	b	vg	dm	el	*		**	*	**	**	†											
Downing.	N. Y.	sc	m	b	g	dk	m		†	*	*	*	*	*	*										
Hicks.	Ky.																								
Lutle.	N. Y.																								
New American.	N. Y.	lc	ml	b	vg	dk	m	**	*	*	*	*	**	**	†										
Stubbs.	South.	lc	vl	b	vgb	d		*		*	*	*	*	*	†										
Travis.	Tex.?																								
Victoria.	Tex.													†	†										

Section 9.—NECTARINES AND PEACHES (*Amygdalus*).

[Key.—Origin: Amer.; Jap.; Eur.; Europe; Jap.; Ont.; Ontario, etc. Form: c, compressed; f, flat; ob, oblate; obl, oblong; ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: b, blushed; c, creamy; g, green; r, red; w, white; y, yellow. Adhesion: c, cling; f, free; sc, semicling. Quality: b, best; g, good; p, poor; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—NECTARINES.

Name.	Description.					Recommendations for the several districts.																				
	Orign.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Boston (<i>Perkin's Seedling</i>).....	Mass.	rov	l	yr	f	g	d	m		*	*	*	*	*		†										
Downy.....	Eng.	rov	l	gr	f	g	d	ve		*	*	*	*	*												
Early Newington (<i>Early Black Newington</i>).....	Eng.	rov	l	gr	c	vg	d	e		*	*	*	*	*												
Early Violet.....	Eng.	rov	l	gr	c	vg	d	e		*	*	*	*	*												
Early Violet (<i>Violette Haire</i>).....	Fr.	r	l	yr	f	vg	d	ve		*	*	*	*	*												
Elrue (<i>Common Elrue</i>).....	Eng.	rov	ml	gr	f	vg	d	l		*	*	*	*	*												
Golden (<i>Fine Gold Fished</i>).....	Eng.	rov	m	yr	c	g	dk	m		*	*	*	*	*												
Napier (<i>Lord Napier</i>).....	Eng.	rov	m	cr	r	g	g	e		*	*	*	*	*												
New White (<i>Neat's White</i>).....	Eng.	r	ml	w	f	vg	dm	e		*	*	*	*	*												
Snow Flake.....	Eng.	rov	ml	gr	f	g	d	l		*	*	*	*	*		†										
Stanwick.....	Eng.	rov	ml	gr	f	g	d	l		*	*	*	*	*												

SUBSECTION 2.—PEACHES.^a

Albright Cling (<i>Abright's Cling</i>).....	Cal.	vl	yl	c	vg	g	l	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Alexander (<i>Alexander's Cling</i>).....	Ill.	r	ml	sr	g	g	ml	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Allen (<i>Allen's Walpole</i>).....	Mass.	r	s	vr	f	g	ml	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Alton [This may be Minnie].....	Mass.	r	s	vr	f	g	ml	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Amelia (<i>Jackson</i>).....	S. C.	rob	l	crv	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Angel.....	Fla.	r	l	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aubert.....	Tex.	r	l	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bailey (<i>Friday Seedling</i>).....	Iowa	r	l	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Banner.....	Ont.	r	l	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Barnard (<i>Early Barnard</i>).....	Ill.	r	ml	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Beers Smock.....	N. J.	r	ml	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Belle (<i>Belle of Georgia</i>).....	Ga.	rob	ml	vr	f	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bequette Cling.....	Tex.	rov	ml	vr	c	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bequette Free.....	Tex.	rov	ml	vr	c	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

^a The distinctive peculiarities of the families or strains of peaches known as Chinese, Persian, and Spanish being more or less ill defined and obscured by crossing or hybridization, a correct classification of varieties under these heads is not deemed practicable.

Section 9.—Nectarines and peaches—Continued.

SUBSECTION 2.—PEACHES—Continued.

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bergen (Bergen's Yellow).....	Amer.	r	l	yr	f	vg	ml	ml	*											*						
Bidwell Early (Bidwell's Early).....	Fla.	ov	m	wt	c	g	ve	ve						*												
Bidwell Late (Bidwell's Late).....	Fla.	ov	m	wt	c	g	l	l																		
Bilvay (Bilvay's Comet).....	Md.	r	vl	w	f	g	vl	vl			*	*														
Bishop (Bishop's Early).....	Cal.	r	l	w	f	g	m	ml			*	*				†										
Blood Pine (Blood Chingstone).....	Amer.	rov	vl	yr	c	g	vl	vl							*				†							
Blood Pine (Blood Creststone).....	Amer.	rov	l	yr	f	g	vl	vl							*											
Bokhara (Bokhara No. 5).....	Del.	r	l	y	f	g	l	l			*															
Brandywine (Prize).....	N. Y.	r	m	wt	f	g	vl	vl																*		
Brett (Mrs. Brett).....	N. Y.	rov	m	cyt	f	g	vl	vl		*																
Brigdon (Garfield).....	N. Y.	r	vl	wt	f	g	vl	vl							*				†			*				
Briggs (Griggs' May).....	Mass.	r	vl	wt	f	g	vl	vl			*	*			*											
Cable (Cable's Late).....	Ohio.	r	vl	wt	f	g	vl	vl				*			*											
California (California Cling).....	Cal.	r	l	yr	c	g	l	l		*					*											
Carman.....	Tex.	r	l	w	c	g	l	l				*			*											
Carpenter (Carpenter Cling).....	Cal.	obl	m	cwb	c	g	l	l				*			*						*					
Chairs (Chairs' Choice).....	Md.	r	l	wt	c	g	vl	vl		*	*	*				†										
Champion.....	Ill.	r	ml	cyt	f	g	vl	vl		*	*	*			*											
Charlotte (Early Charlotte).....	Eur.	ov	l	gwt	f	g	vl	vl		*	*	*			*						†		*			
Chili (Hills' Chili).....	N. Y.	ov	m	wt	f	g	vl	vl		*	*	*			*											
Chinese Cling (China Cling).....	China	r	l	cwt	c	g	vl	vl		*	*	*			*					*						
Chinese Free.....	China	r	l	wt	f	g	vl	vl		*	*	*			*											
Climax (Horn's Hybrid).....	Fla.	rov	s	wt	f	g	vl	vl						*												
Coleman.....	Fla.	c	s	cwb	f	g	vl	vl						*		†										
Colon.....	Fla.	r	l	yr	f	g	vl	vl						*		*										
Columbia (Indian Peach).....	N. J.	r	l	yr	f	p	km	ml		*		†			*											
Conkling (Conkling).....	Amer.	obl	l	wt	sc	g	m	me		*	*	*														
Connet (Connet's Early).....	N. C.	obl	l	wt	f	g	m	me		*	*	*														
Countess.....	Fla.	r	ml	gwt	f	g	dm	ml		*	*	*			*					*						
Crosby (Frost Proof).....	Delaware	r	l	wt	f	g	vl	vl		*	*	*			*											
Delaware (Delaware Favorite).....	Mass.	r	l	gwt	f	g	vl	vl		*	*	*			*											
Deming (Deming's September).....	Del. ?	r	l	wt	f	g	vl	vl		*	*	*			*											
Dewey (Admiral Dewey).....	Ga.	obl	m	yr	c	g	l	e		*		†		*		*										
Dorothy.....	Del.	obl	l	y	f	g	vl	vl		*	*	*			*											
Early China.....	Tex.	ov	m	w	f	g	vl	vl		*	*	*			*					*						
Early Crawford (Crawford's Early).....	N. J.	rov	vl	gwt	sc	g	dm	me		*	*	*			*					*						
Early Michigan (Husted No. 15).....	Mich. ?	r	l	wt	f	g	vl	vl		*	*	*			*					*						

[illegible]

[illegible]

Section 10.—PEARS (*Pyrus communis* and *P. sinensis*).

[**Key**.—**Origin**: Amer., America; Belg., Belgium; Eng., England; Fl., Flanders; For., Foreign; Fr., France; Hol., Holland; Rus., Russia, etc. **Form**: l, irregular; o, oblate; obl, oblong; oblo, obovate; obt, obtuse; ov, ovate; p, pyriform; r, round; t, turbinate. **Size**: l, large; m, medium; s, small; v, very. **Color**: b, brown; c, crimson; g, green; r, red; ru, russet; w, white; y, yellow. **Quality**: b, best; g, good; p, poor; v, very. **Use**: d, dessert; k, kitchen; m, market. **Season**: e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ananas d'Ete (Summer Pineapple).	Hol.	obtp	l	ybru	vg	dm	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Angoulême (Duchesse d'Angoulême).	Fr.	obtp	vl	gyru	vg	dkm	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Anjou (Beurre d'Anjou).	Fr.	obtp	l	gyru	vg	dm	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ansault (Bonne de Puile-Ansault).	Fr.	robt	ms	gyru	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Archange (St. Michael Archange).	Fr.	obtp	l	gyru	vg	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bartlett (Williams Bon Chretien).	Eng.	obtp	l	gyru	vg	dkm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bessemlanka.	Rus.	robo	m	gyru	g	km	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bloodgood (Early Beurre).	N. Y.?	obtp	m	gyru	g	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bordeaux (Duchesse de Bordeaux).	Fr.	robt	m	gyru	vg	dkm	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bosc (Beurre Bosc).	Belg.	obtp	l	gyru	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Boussock (Doyenne Boussock).	Belg.	obtp	l	gyru	vg	dm	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Brandywine.	Pa.	p	m	gyru	vg	dk	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Buffum.	R. I.	obtp	ms	gyru	vg	dk	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chambers (Early Harvest of Kentucky).	(Md.?)	robo	m	yt	g	km	ve	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Clairgave (Beurre Clairgave).	Fr.	p	l	yrb	g	km	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Clapp Favorite (Clapp's Favorite).	Mass.	obtp	l	yrb	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Columbia (Columbia Virgatica).	N. Y.	obo	l	gy	g	km	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Comice (Doyenne de Comice).	Fr.	rop	l	gyru	vg	dm	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Danas Hovey (Dana Hovey).	Mass.	obtp	s	gyru	vg	d	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Diel (Beurre Diel).	Belg.	obtp	l	gyru	vg	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Drouard (President Drouard).	For.	obtp	l	gyru	vg	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dunmore.	Eng.	obtp	l	gyru	vg	dm	me	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Easton Beurre (Beurre Easton).	Fl.	robt	ms	gyru	vg	dm	vl	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Elizabeth (Manning's Elizabeth).	Belg.	obtp	l	gyru	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fertilly.	Belg.	obtp	l	gyru	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Flemish (Flemish Beauty).	Belg.	obtp	l	yrb	p	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fluke.	Belg.	obtp	l	yrb	p	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fred. Clapp (Frederick Clapp).	Mass.	robt	ml	y	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Garber (Garber's Hybrid).	Pa.	robt	l	y	p	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gibbs (Gibbs's Hybrid).	Pa.	robt	l	y	p	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ghislain (Saint Ghislain).	Belg.	p	m	y	g	km	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Giffard (Beurre Giffard).	Fr.	p	m	gyt	vg	dm	e	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gloart Moreau.	Fr.	ovobtp	l	gyt	vg	dm	l	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Golden Russet (Japan Golden Russet).	Jap.	robt	l	cyru	p	km	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Goodale (Goodale's Seedling).	Me.	obtp	l	cyru	p	km	ml	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Grand Isle.	Vt.	robt	l	y	vg	dm	y	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gray Doyenne.	For.	obtp	m	cyru	vg	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hardy (Beurre Hardy).	For.	obtp	l	grub	vg	dm	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Haystack (Emile d'Haystack).	Belg.	obtp	l	yrbu	vg	d	m	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[illegible]

Section 11.—PLUMS (*Prunus*).

[Key.—Origin: Amer., America; Belg., Belgium; Eng., England; Fr., France; Ger., Germany; Jap., Japan; Ont., Ontario; Rus., Russia, etc. Form: c, compressed; f, flattened; ob, obovate; obl, oblong; ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: b, black; br, brown; g, green; p, purple; r, red; v, violet; w, white; y, yellow. Addition: c, cling; f, free; sc, semicling. Quality: b, best; g, good; p, poor; v, very. Use: c, curling; d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—PRUNUS AMERICANA.

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Adh-e-	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Advance.....	Nebr.	ov	l	yt	c	g	km	ml																		
Aitkin (<i>Itasca</i>).....	Minn.	ovf	l	y	c	g	dkm	me																		
American Eagle (<i>Engle</i>).....	Mo.	rov	ml	r	c	g	m	me																		
Blackhawk.....	Iowa.	c	l	r	f	vg	dm	ml																		
Brittlewood.....	Nebr.	rov	l	r	sc	g	m																			
Cheney.....	ov	ov	l	pr	c	vg	dm	e																		
Comfort.....	Iowa.	ov	vs	r	sc	g	d	m																		
Cottrell.....	Minn.	robl	l	yt	c	g	km	me																		
De Soto.....	Wis.	ovc	m	r	c	vg	k	m																		
Forest Garden.....	Iowa.	r	l	pr	c	vg	k	m																		
Free Silver.....	Iowa.	ovc	l	pr	c	g	g	m																		
Gaylord.....	Iowa.	ov	l	pr	c	vg	dkm	me																		
Hammer.....	Iowa.	rov	ml	r	f	vg	km	ml																		
Hawkeye.....	Iowa.	rov	l	yt	c	g	km	ml																		
Louisa.....	Mo.	ov	m	r	c	g	g	ml																		
New Union.....	Minn.	ov	l	yt	c	g	dk	l																		
Ocheeda.....	Minn.	ov	ml	yt	c	vg	dk	m																		
Piper (<i>Piper's Peach</i>).....	Minn.	r	l	yt	c	vg	dk	l																		
Quaker.....	Iowa.	rov	l	r	sc	vg	dk	me																		
Rockford.....	Iowa?	rov	ml	r	c	vg	dk	m																		
Rollingstone.....	Minn.	rov	ml	r	c	vg	dk	m																		
Stella.....	Nebr.	ov	l	r	c	vg	dk	vs																		
Sudward.....	Iowa.	ov	l	yt	c	g	dk	me																		
Surprise.....	Minn.	ov	ml	r	c	vgb	dm	m																		
Terry.....	Iowa.	ml	l	yt	c	e	m	e																		
Weaver.....	Iowa.	ovc	l	yt	sc	g	km	m																		
Wolf.....	Iowa.	rov	ml	yt	f	g	km	m																		
Wonder (<i>Nebraska Wonder</i>).....	Nebr.	r	l	gwy	c	vg	dm	e																		
Wyant.....	Iowa.	ovc	ml	yt	c	g	k	m																		

SUBSECTION 2.—*PRUNUS ANGUSTIFOLIA*.

	ov	s	r	c	D	m	ve					
La.....	ov	3	r	c	D	m	ve					
Cluck.....	ov	ms	r	c	g	l		†				†
Lone Star.....	ov	ms	y	c	g	k						
Tex.....	ov	ms	y	c	g	k						
McCartney.....	r	ml	y	c	g	l		†				
Munson.....	obl	ml	y	c	g	l						
Newman.....	re	ml	yr	c	g	l						
Pottawatomie.....	obl	ml	yr	c	g	l						
Yellow Transparent (Transparent).....	obl	ml	y	c	g	l						

SUBSECTION 3.—PRUNUS CERASIFERA.^a

	S.C.	r	m	c	p	k	e	t	*	
	Tex.	r	ml	f	c	g	km	i	**	*

Includes supposed hybrids.

SUBSECTION 4.—PRUNUS DOMESTICA.

[illegible]

Section 11.—Plums—Continued.

SUBSECTION 4.—PRUNUS DOMESTICA—Continued.

Name.	Description.					Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Ad- be- ston.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Jefferson.....	N. Y.	rov	ml	gy	f	vbg	dm	ml	**			*										*				
Lombard.....	N. Y.	rov	ml	rv	c	g	km	me	*			*										†	*			
McLaughlin.....	Me.	r	m	gy	c	vbg	dm	m	*																	
Moldavka.....	Rus.	oblov	m	y	f	g	dm	me										*								
Monarch.....	Eng.	rov	l	rp	f	vbg	d	m	†																	
Monroe (Monroe Egg).....	N. Y.	rov	ms	y	f	vbg	d	m																		
Niagara (Probably identical with Bradshaw).....	Amer.	rov	ml	pr	f	g	dm	m	*																	
Orleans (Smith's Orleans).....	Eng.	ov	vl	br	f	gv	km	ve	*							*										
Peach.....	Amer.	r	vl	br	f	vbg	km	m	*																	
Pond (Pond's Seedling, Fonhill, Hungarian Prune).....	Eng.	ov	vl	rv			dm	m	*																	
Pride (Shipper's Pride).....	N. Y.	r	l	p		g	km	l	*																	
Prince (Prince's Yellow Gage).....	Amer.	ov	l	p		vbg	dm	e	*																	
Purple Favorite.....	Amer.	r	ml	vp	f	vbg	dm	e	*																	
Purple Gage (Reine Claude Violet).....	Eur.	r	m	vp	f	g	dk	m	*																	
Quackenboss.....	N. Y.	rov	ml	pv	c	g	m	m	†																	
Ravines.....	Que.	ov	l	b	c	g	km	e	*																	
Richland.....	Pa.	r	m	p	f	g	k	m	*																	
Royal Halive.....	Fr.	r	l	p	f	g	dm	e	*																	
St. Ann (Bonne St. Ann).....	Vt.	r	l	p	c	g	m	e	*																	
Saratoga.....	N. Y.	rov	l	pr	c	g	m	e	*																	
Saunders.....	Ont.	ov	l	gy	sc	vbg	cm	m	*																	
Sergeant (Robt de Sergeant).....	Eur.	ov	l	b	sc	vbg	cm	m	*																	
Sharp (Sharp's Emperor, Victoria).....	Eng.	ov	l	r	c	g	km	m	*																	
Shropshire (Shropshire Damson).....	Eng.	ov	s	b	c	g	km	m	*																	
Splendid.....	Pa.	ov	m	yg	f	g	m	me	*																	
Splendor.....	Cal.	oblov	l	rp	f	vbg	dm	ve	*																	
Sugar.....	Cal.	ovf	l	bp	f	vbg	cdm	m	*																	
Tennant.....	Wash.	ovf	l	bp	f	vbg	cdm	ve	*																	
Tragedy.....	Cal.	ov	ml	b	c	g	m	e	*																	
Transparent (Transparent Gage).....	Fr.	rob	ml	gy	c	g	dk	m	*																	
Wales (Prince of Wales).....	Eng.	rob	l	p	f	g	m	me	*																	
Washington.....	Ger.	ov	l	rp	f	vbg	dm	me	*																	
Washington (Bolmer).....	N. Y.	r	ml	gy	f	vbg	dm	me	*																	
Williamsite.....	Oreg.	ov	ml	rbr	f	vbg	dm	me	*																	
Yellow Egg (Deme Aubert).....	Eur.	ov	vl	gy		vbg	ek	m	*																	

Subsection 11.—Plums—Continued.

SUBSECTION 6.—PRUNUS TRIFLORA, INCLUDING HYBRIDS—Continued.

Name.	Origin.	Form.	Size.	Color.	Adhe- sion.	Quality.	Tree. se.	Season.	Recommendations for the several districts.																	
									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Kerr.	Jap.	ov	l	y	c	g	km	m				†														
Maynard.	Cal.	ov	vl	r	f	vg	dkm						*									*				
Normand.	Jap.	r	vl	r	f	vg	dm	ve					*													
Occident (Sultan of Burbank).	Cal.	r	vl	gr	f	vg							*													
Oregon.	Jap.	r	ml	y	f	g	km	e									*		†	*						
Red June (Red Nagai, Shiro-Smomo).	Jap.	ov	ml	r	sc	g	km	ve	†						*		*									
Red May.	Tex.	obl	ml	r	r	g	km								*		*									
Santa Rosa.	Cal.	rc	ml	r	r	vg	km								†		*		*							
Sasuma (Hood).	Jap.	r	ml	p	c	vg	km	ml		*	†	*					*		*		†	*	*	*	*	*
Simon a.	China.	r	l	p	f	p	m	e					*				*		*		*	*	*	*	*	*
Wickson.	Cal.	r	vl	p	f	vg	m	m	†		*		*		*		*		*		*	*	*	*	*	*
Willard (Botan No. 26).	Jap.	rov	s	r	f	p	m	m				†							†			*	*	*	*	*

a Belongs to species *Prunus simonii*.

Section 12.—QUINCES (*Cydonia*).

[KEY.—*Origin*: Amer., America; Fr., France, etc. *Form*: ob, oblate; obt, obtuse; p, pyriform; r, round. *Size*: l, large; m, medium; s, small; v, very. *Color*: g, green; o, orange; y, yellow. *Quality*: b, best; g, good; p, poor; v, very. *Use*: k, kitchen; m, market. *Season*: e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Angers.....	Fr.			gy	g																				
Bourgeat.....	Conn.	obtp	l	gy	y		vl																		
Champion.....	China.		vl	y	g														*						
Chinese (<i>Sinenais</i>).....	Conn.	obtp	l	y	g																				
Fuller.....	Conn.	p	l	oy	g	km																			
Meech (<i>Meech's Prolific</i>).....	Missouri	rob	l	oy	vg	km	m																		
Orange (<i>Apple-Shaped</i>).....	Amer.	rob	vl	oy	vg	km	e													*					
Pear (<i>Pear-Shaped</i>).....	Amer.	obtp	l	y	y	kg	m													*					
Rea (<i>Van Slyke</i>).....	N. Y.	rob	vl	oy	vg	km	me																		
Van Deman.....	Cal.		vl		vg	km	e																		

Section 13.—RASPBERRIES (*Rubus*).

[Key.—*Origin*: Eng., England; Eur., Europe; Fr., France; Ont., Ontario, etc. *Form*: c, conical; ob, obtuse; r, round. *Size*: l, large; m, medium; s, small; v, very. *Color*: b, black; c, crimson; p, pale; pu, purple; r, red; y, yellow. *Quality*: b, best; g, good; p, poor; v, very. *Use*: d, dessert; k, kitchen; m, market. *Season*: e, early; l, late; m, medium.]

SUBSECTION 1.—*RUBUS IDAEUS*.^a

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Clarke.	Conn.	rc	ml	r	vg	dm	me	*							*										
Fastolf (<i>Filby</i>).	Eng.	rc	vl	cr	vg	d	m	*	*																
Frankonia (<i>Naomi</i>).	Fr. ?	rc	l	pr	vg	m	me	*	*										†	†					
Hudson River (<i>Hudson River Antwerp</i>).	Eng.	c	l	r	vg	m	m	*	*										†	†					
Orange (<i>Brinckle's Orange</i>).	Pa.	rc	l	y	vgb	d	ml	*	*					*	*		*						*		
Red Antwerp (<i>Old Red Antwerp</i>).	Eur.	rc	l	r	vgb	dm	m	*	*	*				*	*		*		†	†		*			
Superlative.	Cal. ?	c	m	y	vg	dk	l	**																†	
Vermont.	Vt.	rc	m	y	vg																				

^a Includes possible hybrids.SUBSECTION 2.—*RUBUS NEGLECTUS*.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cardinal.....	Kans.	r	l	r	g	dk	m							*	*	*	*								
Caroline.....	N. Y.	rob	m	y	g	km	e	**	**					*	*	*	*								
Columbian.....	N. Y.	r	vl	pu	g	km	e	**	**	†				*	*	*	*								
Haymaker.....	Pa.	r	m	pr	g	km	me	*	*					*	*	*	*								
Philadelphia.....	N. J.	rob	m	pr	g	km	m	**	**					*	*	*	*								
Reliance.....	N. Y.	rob	m	pr	g	km	m	**	**	*	*	*	*	*	*	*	*								
Shaffer.....	N. Y.	rob	l	pur	g	km	m	**	**	*	*	*	*	*	*	*	*					*			

SUBSECTION 3.—*RUBUS OCCIDENTALIS*.

Locality	rob	l	b	vg	dm	e	+	*	+	*	+	*
Courash	rob	vl	b	vg	dm	e						
Cumberland	rob	vl	b	vg	dm	e						
Doolittle (<i>Doolittle's Black Cap</i>)	r	m	b	vg	km	e	+	*			+	*
Earhart	r	m	b	g	km	el						
Ohio	r	m	b	g	km	me						
Eureka (<i>Mohler</i>)	rob	m	b	g	m	me						
Gregg	rob	l	b	g	dm	me	+	*				
Hilborn	rob	l	b	g	dm	e						
Hoosier				g	km							
Kansas	r	m	b	vg	km	e						
Lotta		m	b	vg	km	m						
McOrmick (<i>Mammoth Cluster</i>)	r	m	b	vg	km	m						
Ind.	r	m	b	g	km	m	+	*				
Mills	r	m	b	vg	km	m						
N. Y.		m	b	vg	km	m						
Neb.	rob	m	b	g	km	e						
Omaha		m	b	g	km	m						
Old	r	m	b	g	km	e						
Palmer	r	m	b	g	km	me						
Sanhegan	r	m	b	g	km	m						
N. H.	r	ms	b	vg	km	m						
Tyler	r	ms	b	vg	km	m						
W. Va.	r	l	b	vg	km	e	+	*			+	*
Winnona	r	l	b	vg	m	e						
Ohio	r	l	b	vg	m	e						

SUBSECTION 4.—*RUBUS STRIGOSUS*.

[illegible]

Section 14.—STRAWBERRIES (*Fragaria*).

[**KEY**—*Origin*: Amer., America; Can., Canada; Ont., Ontario, etc. *Form*: c, conical; l, long; ob, oblate; obl, oblong; r, round. *Size*: l, large; m, medium; s, small; v, very. *Color*: c, crimson; d, dark; l, light; r, red; s, scarlet. *Quality*: b, best; g, good; v, very. *Use*: d, dessert; k, kitchen; m, market. *Season*: e, early; l, late; m, medium; v, very. *Sex*: b, bisexual; p, pistillate.]

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	Sex.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Aroma.	Kans.	c	l	dr	vg	km	l	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bederwood.	Ill.	re	m	ls	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Belt (<i>William Belt</i>).	Ohio	obe	l	dc	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bismarck.	Ark.	re	vl	re	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Brandywine.	Pa.	obe	vl	re	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bruntite.	Ind.	re	vl	dr	vg	d	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bubach (<i>Buback & No. 5</i>).	Ill.	rob	vl	s	vg	m	e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Buster.	Can.?		l	lr	g	m	e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Captain Jack.	Mo.	r	ml	lr	g	m	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cardinal.	Ohio.	re	ml	le	vg	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Carrie.	Va.	obl	l	c	vg	m	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chesapeake.	Md.?						m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Climax.	Md.						m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cloud.	La.	obe	ml	dr	g	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Clyde.	Kans.	oble	l	c	vg	m	e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Commonwealth.	Mass.	oble	l	dr	vg	m	l	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Crawford.	Ohio.	re	l	c	vg	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Crescent (<i>Yvescent Seedling</i>).	Conn.	re	m	ls	vg	m	e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cumberland (<i>Cumberland Triumph</i>).	Pa.	rob	vl	ls	vg	d	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dollar.	N. J.?	re	l	le	vg	m	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dorman (<i>Uncle Jim</i>).	Mich.?	r	vl	lsc	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Downing (<i>Charles Downing</i>).	Ky.	re	ml	ds	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dunlap (<i>Senator Dunlap</i>).	Ill.	re	m	dr	vg	dkm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Enhance.	Ohio.	c	l	le	vg	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Enormous.	Ill.	obe	vl	dr	g	dm	ml	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Eureka.	Ohio.	r	ml	lr	g	dm	ml	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Excelsior.	Ark.	c	m	r	g	dm	ve	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fendall.	Md.	re	vl	lr	g	d	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gandy.	N. J.	c	l	le	vg	dm	l	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Glen Mary.	Pa.	re	vl	c	gvg	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Goodluck.	Ohio.	robe	l	le	vg	dm	e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Greenville.	N. J.	oble	l	s	gvg	dm	m	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Haverland.	Va.						e	p	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hedlin.	S. C.	c	ml	dc	vg	dm	m	b	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hoffman.	Oreg.								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hood River.									*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[illegible]

Section 15.—NUTS.

SUBSECTION 1.—ALMONDS (*Amgdalus communis*).

[KEY.—Origin: Cal., California; Eur., Europe; Tex., Texas. Form: b, broad; l, long; m, medium. Flavor: s, sweet. Quality: g, good; v, very. Shell: s, soft; t, thin; v, very.]

Name.	Description.					Recommendations for the several districts.																		
	Origin.	Form.	Flavor.	Quality.	Shell.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
California (<i>California White</i>).....	Cal...			vg	t																			
Chillense.....	Cal...			vg	s																			
Commercial (<i>Harriott's Seedling</i>).....	Cal...	l	s	vg	t																			
Drake (<i>Drake's Seedling</i>).....	Cal...	b		vg	s																			
Eureka.....	Cal...			vg	s																			
Golden State.....	Cal...	ml		g	s																			
I. X. L.....	Cal...	bl		vg	s																			
Jordan (<i>California Jordan</i>).....	Cal...			vg	s																			
Lassen.....	Eur...	b		vg	t																			
Langsdorff.....	Eur...																							
Nonpareil (<i>Exro</i>).....					vt																			
Prolific.....																								
St. Joseph.....																								
Texas (<i>Texas Prolific</i>).....	Tex...																							

SUBSECTION 2.—CHESTNUTS (*Castanea*).

[Key.—*Origin*: Cal., California; Del., Delaware; Fr., France; Jap., Japan; N. J., New Jersey, etc. *Size*: l, large; m, medium; s, small; v, very. *Quality*: b, best; g, good; v, very.]

Name.	Description.			Recommendations for the several districts.																		
	Species.	Origin.	Size.	Quality.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alpha.....	<i>C. crenata</i>	N. J.	ml	g	*																	
Anderson.....	<i>C. sativa</i>	N. J.	ml	g																		
Bartram.....	<i>C. sativa</i>	Pa.	m	g	+																	
Beta.....	<i>C. crenata</i>	N. J.	m	g	+																	
Biddle.....	<i>C. crenata</i>	N. J.	m	g	+																	
Black.....	<i>C. crenata</i>	N. J.	ml	g	+																	
Coe.....	<i>C. crenata</i>	Cal.	l	g	+																	
Combale (<i>Marron Combale</i>).....	<i>C. sativa</i>	Fr.	l	g	+																	
Comfort.....	<i>C. sativa</i> ?	Pa.	ml	gvg	+													*			*	
Cooper.....	<i>C. sativa</i> ?	N. J.	ml	gvg	+							†										
Corson.....	<i>C. sativa</i>	Pa.	ml	gvg	+																	
Dager.....	<i>C. sativa</i>	Del.	ml	gvg	+																	
Darlington.....	<i>C. sativa</i>	Del.	ml	gvg	+																	
Felton.....	<i>C. crenata</i>	Del.	ml	gvg	+																	
Hale.....	<i>C. crenata</i>	Cal.	ml	gvg	+																	
Hannum.....							†	†	*													
Hathaway.....	<i>C. dentata</i>	Mich.	s	vgb	†																	
Kent.....	<i>C. crenata</i>	N. J.	ml	g	+																	
Kerr.....	<i>C. crenata</i>	N. J.	l	g	+																	
Killen.....	<i>C. crenata</i>	N. J.	vl	g	+																	
McFarland.....	<i>C. crenata</i>	Cal.	vl	g	+							†										
Martin.....	<i>C. crenata</i>	N. J.	l	g	+																	
Miller.....	<i>C. sativa</i> ?	Pa.	m	g	+																	
Moncur.....	<i>C. sativa</i>	Del.	m	g	+																	
Numbo.....	<i>C. sativa</i>	Pa.	ml	gvg	+																	
Paragon.....	<i>C. sativa</i>	Pa.	ml	gvg	+													*	*			
Parry.....	<i>C. crenata</i>	Jap.	vl	gvg	+																	
Prolific.....	<i>C. crenata</i>	Jap.	g	g	+																	
Reliance.....	<i>C. crenata</i>	N. J.	m	g	+																	
Ridgeley.....	<i>C. crenata</i>	Del.	ml	g	+																	
Rochester.....	<i>C. sativa</i>	Del.	ml	gvg	+													*				
Scott.....																						
Success.....	<i>C. sativa</i>	N. J.	m	g	+																	
Superb.....	<i>C. crenata</i>	N. J.	l	gvg	+																	
Styer.....	<i>C. sativa</i>	Pa.	m	g	+																	

Section 15.—Nuts—Continued.

SUBSECTION 3.—FILBERTS AND HAZELNUTS (*Corylus*).

[Key.—Origin: Cal., California; Eur., Europe; Fr., France, etc. Form: l, long; o, oval; ob, oblong. Size: l, large; m, medium; v, very. Quality: b, best; g, good; v, very.]

Name.	Description.				Recommendations for the several districts.																	
	Origin.	Form.	Size.	Quality.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Du Chilly.....	Eur.....	ob	vl	vg															*		*	*
Fertile de Contord.....																						*
Nottingham.....																						*
Purple Leaf.....	Eur.....	ob	l	g						*												

SUBSECTION 4.—PECANS (*Hicoria pecan*).

Alley.....																							
Centennial.....	La.....	ob	vl	vg						†	*												
Curtis.....										†													
Delmas.....																							
Frotscher (<i>Frotscher Egg Shell, Oleifer</i>).....	La.....	ob	l	vg				†	**	*													
Georgia (<i>Georgia Giant</i>).....																							
Hollis (<i>Posta Select</i> , in part).....																							
Jewett.....	Miss.....	o	vl	vg																			
Money Maker.....																							
Palist.....																							
Peerless.....																							
Post (<i>Posta Select</i> , in part).....																							
Rome (<i>Rome, Columbia, Columbian, Pride of the Coast, Bourgeois</i>).....																							
Russell.....	Miss.....	ob	l	vg						*													
San Saba.....	Tex.....	o	m	vgb						*													
Schley.....																							
Stuart (<i>Castanet</i>).....	Miss.....	rob	l	vg				†	**	*													
Success.....																							
Teche (<i>Frotscher</i> , of some).....																							
Van Deman (<i>Paragon</i>).....	Miss.....	ob	l	vg				†	**	†	*												
Young.....																							

SUBSECTION 5.—PERSIAN, ENGLISH, OR EUROPEAN WALNUTS (*Juglans regia*).

Localities	Cal	lov	vi	vg	+
Chabertia					
Ford (<i>Ford Soft Shells</i>)	Cal	lov	vi	vg	+
Franquette	Fr	lov	vi	vgb	+
Mayette	Fr	lov	vi	vg	+
Mission (<i>Los Angeles</i>)	Cal	rov	ml	g	
Parisienne	Fr	rob	l	vg	
Piacentia (<i>Piacentia Perfection</i>)					
Prosparturiens	Fr	ov	in	vg	
Santa Rosa					
Von Rey					

Division II.—SUBTROPICAL AND TROPICAL FRUITS.

This division includes such species only as, under cultivation or otherwise, have so far varied that the departures from the original types are recognized under varietal names.

The climate of the portion of Florida lying south of 27° north latitude is so far modified by its semi-insular position, together with the softening influence of the almost tepid waters of the adjacent Gulf Stream, as practically to adapt it to the successful cultivation of many strictly tropical fruits. Such, therefore, as are recommended for cultivation in this region are indicated by the letter *s* in connection with the starring of District No. 6, of which this territory forms a part. A few of the more hardy subtropical fruits, though not succeeding in all portions of District No. 6, are successful in favored localities in adjacent portions of districts 5 and 7.

Section 1.—CITRUS FRUITS.

[Key.—Origin: Braz., Brazil; Fla., Florida; For., Foreign; Jap., Japan; Port., Portugal, etc. Form: o, oblate; ob, oblong; ov, oval; r, round. Size: l, large; m, medium; s, small; v, very. Color: d, dark; l, light; o, orange; r, red; y, yellow. Quality: b, best; g, good; p, poor; v, very. Use: d, dessert; k, kitchen; m, market. Season: e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—CITRONS (*Citrus medica*).

Name.	Description.						Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.																			
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Lemon. Lymon. Orange.	For. For. For.	ov ov r	vl m s	oy oy oy	dg dg g	k k k								sg sg sg												

SUBSECTION 2.—KUMQUATS: *Syn. KINKANS (Citrus japonica)*.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Marumi.....	Jap.	r	s	oy		dkm							*												
Nagami.....	Jap.	ob	s	oy		dkm							**												

SUBSECTION 3.—LEMONS (*Citrus limonum*).

[illegible]

SUBSECTION 4.—LIMES (*Citrus limetta*).

[illegible]

SUBSECTION 5.—MANDARINS (*Citrus nobilis*).

	For.	o	m	lo	d		*
	Fia	o	mi	or	vg dm		*
China							*
Dancy (<i>Dancy tangerine</i>)							*
Oneco							*
Satsuma	Jap.	o	m	o	vg dm		*
Tangerona	Braz.	o	m	lo	vg dm		*

SUBSECTION 6.—POMELOS: *syn.* GRAPEFRUIT (*Citrus decumana*).

Bowen.	Fia	r	s	ly	g	dm	lm	*
Conner (<i>Conner's Prolific</i>)								†
Duncan.								***
Hart.	Fia	r	i	oy	vg	dm	l	***
Mammoth.	For.	r	s	oy	vg	dm		*
Marsh (<i>Marsh Seedless</i>)	Fia	r	vl	ly	vg	dm	l	*
Pernambuco.	Braz.	r	ml	ly	vg	dm	em	***
Royal.	Fia	r	ml	ly	g	dm	lm	*
Triumph.	Fia	r	ms	ly	g	dm	lm	*
Walters.	Fia	r	ml	ly	g	dm	lm	***
Woodworth.								*

Section 1.—*Citrus fruits*—Continued.
 SUBSECTION 7.—SWEET ORANGES (*Citrus aurantium sinensis*).

Name.	Description.				Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Acapulco.	For.	r	l	o	g	dm	m																		
Bahia (<i>Washington Navel</i>) a	Braz.	rov	vl	o	vgb	dm	em																		
Bessie.	Fla.	r	l	o	vg	dm	l					*													
Blood.												*													
Boone.	Fla.	r	ml	lo	g	dm	ve					*													
Centennial.	Fla.	r	m	o	vgb	dm	em					*													
Comer (<i>Comer Seedless</i>).												†													
Dugat.					vg																				
Ellwood.																									
Enterprise (<i>Enterprise Seedless</i>).	Fla.	r	m	o	g	dm	e					*													*
Foster.	Fla.	r	m	o	g	dm	e					*													
Hart (<i>Hart's Late</i>).	For.	ov	m	o	vg	dm	vl					*													
Homosassa.	Fla.	r	m	o	vg	dm	m					*													
Imperial (<i>Imperial Blood</i>).	Fla.	r	m	or	g	dm	e					*													
Jaffa.	For.	r	m	o	vgb	dm	m					*													
Majorca.	For.	r	m	o	b	dm	lm					*													
Maltese Blood.	For.	ov	sm	or	b	dm	m					*													
Mars (<i>Mars' Best</i>).	Fla.	r	sm	o	g	dm	m					*													
Mediterranean (<i>Mediterranean Sweet</i>).	For.	ov	l	o	g	dm	l					*													
Nonpareil.	For.	ov	l	o	Vg	dm	em					*													
Paper Rind (<i>Paper Rind St. Michael</i>).	For.	ov	s	lo	g	dm	lm					*													
Parson (<i>Parson Brown</i>).	Fla.	ov	m	o	g	dm	e					*													
Pineapple.	Fla.	r	vl	oy	vg	dm	m					*													
Ruby.	Fla.	r	m	o	vg	dm	em					*													
St. Michael.	For.	r	m	o	vg	dm	m					*													
Thompson (<i>Thompson Improved</i>).	Cal.	rov	vl	o	vg	dm	em					*													
Valencia (<i>Valencia Late</i>).	For.	ov	l	lo	o	vgb	dm					*													
Vinous (<i>Madam Vinous</i>).	Fla.	r	m	o	vgb	dm	m					*													

a Well known on the Pacific coast under its synonym, Washington Navel.

Section 2.—**FIGS** (*Ficus carica*).

[**KEY.—Origin:** For., Foreign; Sp., Spain. **Size:** l, large; m, medium; s, small; v, very. **Color:** a, amber; b, black; bl, blue; br, brown; g, green; p, purple; r, red; v, violet; w, white; y, yellow. **Quality:** b, best; g, good; p, poor; v, very. **Use:** c, curling; d, dessert; k, kitchen; m, market.]

Name.	Description.						Recommendations for the several districts.																		
	Origin.	Size.	Color.		Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Skin.	Flesh.																					
Adriatic (<i>White Adriatic</i>).	For.	l	gy	r	g	cdk						*	*	*							*				**
Ascolano.	For.	ml	rb	r	vbg	dkm						*	*	*									*		**
Black Ischia.	For.	m	br	r	vbg	dkm						*	*	*											*
Bourjassotte Grise.	For.	lv	va	a	g	dkm						*	*	*											*
Brunswick (<i>Madonna</i>).	For.	lv	va	a	g	dkm						*	*	*											*
Calimyrna.	For.	s	rva	a	vbg	dkm						*	*	*											*
Celeste (<i>Celestia</i>).	For.	vs	vbr	r	vg	dkm						*	*	*											*
Early Violet.	For.	m	gy	vp	g	dkm						*	*	*											*
Endrich.	For.	m	gy	vp	g	dkm						*	*	*											*
French.	For.	ml	bl	r	g	dkm						*	*	*											*
Genoa (<i>Blue Genoa</i>).	For.	s	blg	r	g	dkm						*	*	*											*
Ischia (<i>White Ischia</i>).	For.	ml	y	r	vbg	dkm						*	*	*											*
Lemon.	For.	ml	y	r	vbg	dkm						*	*	*											*
Magnolia.	For.	ml	yw	a	g	cdk						*	*	*											*
Marsellaise (<i>Marsillaise White</i>).	For.	ml	rv	r	vbg	cd						*	*	*								*			**
Mission (<i>California</i>).	Sp.	l	rv	r	vbg	cd						*	*	*								*			**
Monaco Bianco.	For.	vl	blg	r	vbg	d						*	*	*											**
Narbus (<i>Golden Narbus</i>).	For.	vl	blg	r	vbg	d						*	*	*											**
Nerli (<i>White Nerli</i>).	For.	ml	br	r	vg	d						*	*	*											**
Osborn (<i>Osborn Prolific</i>).	For.	ml	br	r	vg	d						*	*	*											**
Provence (<i>Provence Blanche</i>).	For.	l	br	r	vg	d						*	*	*											**
Reine Blanche.	For.	vl	yb	r	vg	d						*	*	*								*		*	**
San Pedro Black.	For.	ml	br	r	vbg	dkm						*	*	*								*	*	**	**
Turkey (<i>Brown Turkey</i>).	For.	ml	br	r	vbg	dkm						*	*	*								*	*	**	**
White Smyrna.	For.	vl	w	w	p	km						*	*	*								*	*	**	**
Zimetsa.	For.	vl	w	w	p	km						*	*	*								*	*	**	**

Section 3.—JAPANESE PERSIMMONS (*Diospyros kaki*).

[*Key*.—*Origin*: Jap. Japan; Tex., Texas. *Form*: c, conical; o, oblate; ob, oblong; obo, obovate; p, pointed; r, round. *Size*: l, large; m, medium; s, small; v, very. *Color*: br, brown; c, carmine; d, dark; o, orange; r, red; s, salmon. *Quality*: b, best; g, good; m, medium; p, poor; v, very. *Use*: d, dessert; m, market. *Season*: e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Costata.....	Jap...	rep	m	cr	g	dm	l						**	*											
Goshio.....	Jap...	obop	vl	br	g	dm	e				†	*	*	*											**
Hachiya.....	Jap...	robo	l	or	pg	m	m					*	*	*	*										
Kiyakume.....	Jap...	r	l	r	g	dm	m					*	*	*	*										
Krokuma.....	Jap...												*												
Mazelli.....	Tex...																								
Munson (<i>Munson Seedling</i>).....	Tex...																								
Okame.....	Jap...	ro	l	brc	g	dm	em				†	*	*	*	†										
Taber (<i>Taber 129</i>).....	Jap...	rp	m	or	g	dm	ve					*	*	*	*										
Tanenashi.....	Jap...	rep	l	br	vgb	dm	m				†	*	*	*	*										
Triumph.....	Jap...												*	*	*	*									
Tsuru.....	Jap...	obp	l	br	pg	m	vl					*	*	*	*										
Yeddoischi.....	Jap...	ro	ml	dr	g	dm	m					*	*	*	*										
Yemon.....	Jap...	rep	l	cr	pg	m	m					*	*	*	*										
Zengi.....	Jap...	ro	s	dr	pg	dm	ve					*	*	*	*										

Section 4.—GUAVAS (*Psidium*).

[*Key*.—*Origin*: Mex., Mexico; S. A., South America. *Form*: r, round. *Size*: m, medium; s, small. *Color*: g, green; y, yellow. *Quality*: g, good; p, poor. *Use*: d, dessert; k, kitchen; m, market. *Season*: a, autumn; s, summer.]

Name.	Description.					Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cattley (<i>Strawberry</i>).....	S. A.	r	m	g	pg	dkm	as																		**
Chinese (<i>Mexiana</i>).....	Mex.	r	sm	y	pg	km	as																		*

Section 5.—OLIVES (*Olea europea*).

[*Key*.—*Origin*: Cal., California; Fr., France; Sp., Spain. *Form*: o, oblique; ob, obovate; ov, oval; r, round. *Size*: l, large; m, medium; v, very. *Color*: b, black; d, dark; p, purple.]

Name.	Description.						Recommendations for the several districts.																		
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ascolano.....	Italy	ovob	vl	p																					*
Macrocampa.....	Sp	rov	l	pb																					**
Manzanillo.....	Cal	ov	ml	pb																					**
Mission.....	Cal	ov	ml	pb																					**
Nevadillo (Nevadillo Blanco).....	Sp	ovo	m	pb																					*
Queen.....	Fr. 7	ovo	m	b																					*
Rubra.....	Fr. 7	ovo	m	b																					*
Santa Catarina.....	Sp	ovb	vl	p																					**
Sevillano.....	Sp	ovb	vl	p																					**
Uvaria.....	Fr.	ov	m	pb																					*

Section 6.—PINEAPPLES (*Ananas sativus*).

[*Key*.—*Origin*: For., Foreign. *Form*: c, conical; ob, oblong; r, round. *Size*: l, large; m, medium; v, very. *Color*: d, dark; r, red; y, yellow. *Quality*: b, best; g, good; v, very. *Use*: d, dessert; k, kitchen. *Season*: s, summer.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abachi (<i>Abakka</i>).....	For.	ob	ml	dy	vg	dk	s						%												
Cayenne (<i>Smooth Cayenne</i>).....	For.	c	vl	y	vgb	dk	s						%												
Golden.....	Natal.												%												
Porto Rico.....	For.	r	vl	y	g	dk	s						%												
Queen.....	For.												%												
Spanish (<i>Red Spanish</i>).....	For.	r	ml	ry	g	dk	s						%												

Section 7.—POMEGRANATES (*Punica granatum*).

[KEY.—Origin: Amer., American. Form: ov, oval; r, round. Size: l, large; m, medium; s, small. Color: r, red; v, violet; y, yellow. Quality: b, best; g, good; vg, very good. Use: d, dessert. Season: e, early; l, late; m, medium.]

Name.	Description.						Recommendations for the several districts.																		
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acid.....	Amer.	ov	vl	ry	g	d	a							**											
Dwarf.....	Amer.	r	s	r	vg	d	a					*		**											
Everbearing.....														†											
Jackson.....														†											
Rhodia.....																									
Spanish Ruby.....														**											
Secret (<i>Large Succul.</i>).....	Amer.	r	vl	r	b	d	a					*		**											
Violet.....	Amer.	r	vl	v	b	d	a					*		**											

Section 8.—BANANAS (*Musa sapientum*).

Name.	Description.					Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Baracca (<i>Red Baracca</i>).....													%	%											
Dwarf.....													%	%											
Hart (<i>Hart Choice</i>).....													%	%											
Horse.....													%	%											
Martinique.....													%	%											

Section 9.—AVOCADOS (*Persea gratissima*).

[KEY.—Origin: Cal., California. Form: c, conical; obl, oblong; ov, oval; r, round. Size: l, large. Color: g, green; pu, purple; y, yellow. Quality: g, good; v, very.]

Name.	Description.							Recommendations for the several districts.																		
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Baldwin.....	Cal	obl	l	pu	vg								sg													*
Chappelow.....		c	l	yg	sg								sg													
Family.....													sg													
Follock.....													sg													
Trapp.....		r	l	gy	vg								sg													

Section 10.—MANGOS (*Mangifera indica*).

[KEY.—Form: obl, oblong; r, round. Size: l, large. Color: g, green; r, red; y, yellow. Quality: g, good; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Gordon (<i>General Gordon</i>).		obl	l	fy	avg																				
Mulgotha.		robl	l	yr	vg								*g												

Section 11.—LOQUATS (*Eriobotrya japonica*).

Name.	Description.					Recommendations for the several districts.																			
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Advance.....																									
Early Red.....																									
Premium.....																									
Victor.....																									
Euallia.....																									

Division III.—NATIVE FRUITS.

PAPAW (*Asimina triloba*).

[KEY.—*Origin*: Ind., Indiana. *Form*: obl, oblong. *Size*: l, large; v, very. *Color*: d, dark; y, yellow. *Quality*: g, good; v, very. *Use*: d, desert. *Season*: m, medium.]

Name.	Description.					Recommendations for the several districts.																				
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
•																										
Uncle Tom.....	Ind...	obl	vl	dy	vg	d	m				*				*											

PERSIMMON (*Diospyrus virginiana*).

Name.	Description.							Recommendations for the several districts.																		
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Early Golden.....															*											
Miller.....															*											
Josephine (<i>American Honey</i>).....														*	*											

CODE OF NOMENCLATURE OF THE AMERICAN POMOLOGICAL SOCIETY.

The nomenclature used in this bulletin is in accordance with the rules of the American Pomological Society, adopted at Boston, Mass., on September 10, 1903, the complete text of which follows:

PRIORITY.

RULE 1. No two varieties of the same kind of fruit shall bear the same name. The name first published for a variety shall be the accepted and recognized name, except in cases where it has been applied in violation of this code.

A. The term "kind" as herein used shall be understood to apply to those general classes of fruits which are grouped together in common usage without regard to their exact botanical relationship, as apple, cherry, grape, peach, plum, raspberry, etc.

B. The paramount right of the originator, discoverer, or introducer of a new variety to name it, within the limitations of this code, is recognized and emphasized.

C. Where a variety name through long usage has become thoroughly established in American pomological literature for two or more varieties, it should not be displaced nor radically modified for either sort, except in cases where a well-known synonym can be advanced to the position of leading name. The several varieties bearing identical names should be distinguished by adding the name of the author who first described each sort, or by adding some other suitable distinguishing term which will insure their identity in catalogues or discussions.

D. Existing American names of varieties which conflict with earlier published foreign names of the same or other varieties, but which have become thoroughly established through long usage, shall not be displaced.

FORM OF NAMES.

RULE 2. The name of a variety of fruit shall consist of a single word.

A. No variety shall be named unless distinctly superior to existing varieties in some important characteristic, nor until it has been determined to perpetuate it by bud propagation.

B. In selecting names for varieties the following points should be emphasized: Distinctiveness, simplicity, ease of pronunciation and spelling, indication of origin or parentage.

C. The spelling and pronunciation of a varietal name derived from a personal or geographical name should be governed by the rules which control the spelling and pronunciation of the name from which it was derived.

D. A variety imported from a foreign country should retain its foreign name, subject only to such modification as is necessary to conform it to this code or to render it intelligible in English.

E. The name of a person should not be applied to a variety during his life without his express consent. The name of a deceased horticulturist should not be so applied except through formal action by some competent horticultural body, preferably that with which he was most closely connected.

F. The use of such general terms as seedling, hybrid, pippin, pearmain, beurre, rare-ripe, damson, etc., is not admissible.

G. The use of a possessive noun as a name is not admissible.

H. The use of a number, either singly or attached to a word, should be considered only as a temporary expedient while the variety is undergoing preliminary test.

I. In applying the various provisions of this rule to an existing varietal name which has through long usage become firmly embedded in American pomological literature, no change shall be made which will involve loss of identity.

RULE 3. In the full and formal citation of a variety name, the name of the author who first published it shall be given.

PUBLICATION.

RULE 4. Publication consists (1) in the distribution of a printed description of the variety named, giving the distinguishing characters of fruit, tree, etc., or (2) in the publication of a new name for a variety which is properly described elsewhere; such publications to be made in any book, bulletin, report, trade catalogue, or periodical, providing the issue bears the date of its publication and is generally distributed among nurserymen, fruit growers, and horticulturists; or (3) in certain cases the general recognition of a name for a propagated variety in a community for a number of years shall constitute publication of that name.

A. In determining the name of a variety to which two or more names have been given in the same publication, that which stands first shall have precedence.

REVISION.

RULE 5. No properly published variety name shall be changed for any reason except conflict with this code, nor shall another variety be substituted for that originally described thereunder.

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[Continued on page 3 of cover.]

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 152.

B. T. GALLOWAY, *Chief of Bureau.*

THE LOOSE SMUTS OF BARLEY AND WHEAT.

BY

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AND

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 1, 1909.

SIR: I have the honor to transmit herewith a technical paper entitled "The Loose Smuts of Barley and Wheat," containing the results of recent researches by the Office of Grain Investigations into the life histories of loose smuts and the determination of methods for their prevention. These smuts have been on the increase in recent years, as satisfactory means of combating them have been unknown. The accompanying paper, prepared by E. M. Freeman, formerly Pathologist in the Office of Grain Investigations, at present a collaborator of the same Office, and Edward C. Johnson, Pathologist in the Office of Grain Investigations, not only gives much new information on the life histories of these important grain smuts, but also demonstrates a practical method for their prevention. I therefore recommend that it be published as Bulletin No. 152 of the special series of this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE LOOSE SMUTS OF BARLEY AND WHEAT.

INTRODUCTION.

The loose smuts of barley and wheat have often been considered diseases of minor importance. Although this estimate may have been justifiable ten or fifteen years ago, it certainly is not warranted at the present time. In Wisconsin and Minnesota losses from loose smut of barley of 5 to 10 per cent are not at all uncommon, while greater losses sometimes occur. Loose smut of wheat often prevails to the extent of 3 or 4 per cent in Minnesota, and considerably higher percentages have been observed in that State and in other States. Losses exceeding half of the crop have been reported in a few cases, although these are comparatively rare. Undoubtedly the greatest loss at present is occasioned by the wide distribution of these smuts. They are practically coextensive with their host plants, and though they occur usually in small quantities the damage in the aggregate is large. They often are entirely unnoticed on account of their earliness and the absence of any conspicuous sign of them at harvest time.

The loose smuts of barley and wheat are to be considered enemies to cereal culture not only on the basis of the present damage which they cause, but also on account of the possibilities of their power of increase under favorable conditions. The barley smut in particular has demonstrated its power in Minnesota and Wisconsin, where the farmers are now wide awake to the danger. The seed of wheat and barley is infected one year, but does not produce a smutted crop until the next season, while the methods necessary for combating the disease are not simple or easily applicable. Such facts emphasize the dangerous nature of these fungous pests and make the determination of any successful method of prevention especially desirable.

DESCRIPTION OF LOOSE SMUT OF BARLEY.

There are two smuts of barley common in this country. The loose smut (*Ustilago nuda* (Jens.) Kell. & Sw.) is easily distinguished from the covered smut by its earlier appearance, by its olive-green spore mass as compared with a black spore mass in the latter, and by

the early shedding of the spores, which are blown off by the wind almost as soon as the smutted head comes out of the leaf sheath. In covered smut the spore mass is compact and often persists as smut balls in the harvested grain. (See Pl. I, *d*, *e*, and *f*.)

The smutted plants head earlier as a rule than those not infected. The heading in both infected and normal plants is prolonged throughout a period of from four to fourteen days, depending on external conditions. However, the period of maximum smut development in a field always occurs at the maximum flowering time of the barley. Scattering heads on both infected and healthy plants appear until the time of harvest. Usually the smutted heads are elevated rapidly above those of the healthy plants, thus giving opportunities for a wide distribution of spores by air currents. The light weight of the smutted heads also assists them in maintaining an upright position in a heavy wind. In general, when a plant is infected every head is smutted. Occasionally, however, plants are found with some smutted and some sound heads. (See Pl. VI.)

In a smutted head usually every spikelet and every kernel is smutted. To this again there are not infrequent exceptions. When spikelets in an infected head escape the smut they ordinarily occur at the top. (See Pl. III, *b*.) In the field such heads are commonly found late in the season, i. e., shortly before harvest. Sometimes they occur in artificially infected plants when infection has taken place previous to the full flowering period.

In a smutted head as a rule each spikelet is entirely transformed into a smut mass. (See Pl. II.) The ends of the awns, however, frequently escape. These often remain as weak threadlike bodies on the end of the smut masses. The rachis is never destroyed, and persists as a naked stalk after the spores have been blown off. In a smutted plant the smut occasionally extends to the top of the leaves, and large bract-like bodies, likewise smutted, are sometimes formed at the bases of the heads. These are probably the basal glumes or entire spikelets stimulated to abnormal development by the fungus. (See Pl. III, *e*.)

The smut masses when the head first appears are covered by a delicate grayish membrane. This soon bursts and sets free the powdery spores, which in a few days are blown off by the wind. In some seasons many of the latest formed smutted heads remain hard and black and fail to release their spores. The head, therefore, does not become powdery, but retains its mature form, and the spores are apparently never distributed. (See Pl. III, *d*.) In a normal smut head the smut mass is olive-green in color. The spores are approximately spherical and measure 5 to 7 by 5 to 6.5 μ in diameter. Seen

under the microscope they are lighter colored on one side than on the other.

That there is a variation in the susceptibility to infection in different barleys seems clear from the fact that in variety tests on one-tenth-acre contiguous plats about equally exposed the different varieties show varying amounts of smut. The order of susceptibility in eight selected barley varieties, from the worst smutted to those showing no smut in 1906, was maintained in 1907. Whether this is due to an innate protoplasmic resistance during the stage of floral infection or whether it is due to differences in the time of maximum flowering period or to differences in the degree of opening of the glumes in the several varieties is not yet clear. Practically all barley varieties, both two-rowed and six-rowed, which have come under the writers' observation contain, however, some loose smut.

DESCRIPTION OF LOOSE SMUT OF WHEAT.

The loose smut of wheat (*Ustilago tritici* (Pers.) Jens.) in almost all of its characters resembles the loose smut of barley. There is a more striking difference between it and stinking smut, or bunt, of wheat than there is between the loose and covered smuts of barley. The bunt of wheat transforms only the kernels into smut balls, which do not break until the wheat is thrashed and often remain intact in the thrashed grain. The loose smut of wheat on the other hand discharges its spores even earlier than does the barley loose smut. (See Pl. I, *a*, *b*, and *c*.) The smut masses of the former are usually broken before the head gets out of the sheath, a feature not common in the latter. Loose smut of wheat is similar, however, to the loose smut of barley in all of its essential features, as just described. (See Pls. IV and V.)

The following slight differences may be noted: The smut appears at the flowering time of wheat, and thus usually in spring wheats a little later than in barley. Nothing has yet been observed in wheat similar to the bract-like or leaf-like bodies at the base of the smutted spike of barley. (See Pl. III, *e*.) The smut mass in wheat is darker than that in barley and approaches coal-black. The membrane covering it is even more delicate and breaks usually before the head is exposed to the air. The spores are spherical, 5.5 to 7.5 by 5 to 6 μ in diameter, and under the microscope are lighter colored on one side than on the other. The variation in susceptibility among wheat varieties is perhaps more marked than among the barleys. Some of the bearded spring wheats seem to be infected more easily than the common Bluestems. The smut is found, however, in practically all classes and probably all varieties of wheats.

The following records of loose smut of wheat were obtained in 1906 at McPherson, Kans., by Mr. V. L. Cory, for the Office of Grain Investigations:

The greatest quantities of loose smut in wheat occurred in two Japanese varieties, a Roumanian wheat and a Kansas hybrid (Turkey Red $\times$ Zimmerman). The last-named variety gave 15 per cent. The appearance of this amount of smut is not readily explained. One Japanese variety (G. I. No. 1184-1, Japanese No. 1) contained 9 per cent of smut, and Onigara, another Japanese variety (G. I. No. 1695), 6 per cent. The Roumanian wheat contained about 8 per cent. The last three wheats are all early, and it is possible that on account of their earliness they are more easily subject to the wind-blown spores of loose smut than the later varieties. This does not explain the susceptibility of the hybrid mentioned above, as this was not an early variety. In regard to earliness of ripening, the Japanese wheats mentioned matured about June 22 or 23. The earliest wheat at the station was a Zimmerman which ripened June 16. It is an interesting fact that still another Japanese wheat (Japanese No. 4), which ripened at the time of the Zimmerman, was free from smut.

LIFE HISTORY STUDIES OF LOOSE SMUTS.

HISTORICAL REVIEW OF STUDIES.

In 1895^a and 1896^b Frank Maddox, of Launceston, Tasmania, produced what appears as the first evidence of "floral" or intra-seminal infection in the loose smuts of wheat and barley. In experiments undertaken to devise methods of prevention in the case of the loose smut of wheat he demonstrated that the ovaries of the wheat in the flowering stage could be "artificially smutted" by the application of the spores of loose smut. The grains developed from these ovaries were apparently normal, but when planted the following year almost invariably produced smutted plants. Mr. Maddox states:

The loose smut germs on the grain or mixed with the soil are harmless and will not produce the disease. Artificially smutted is putting the smut germs on the ovary about the time the pollen is ripe, which will always reproduce the disease the following year. Pots sown in 1894, with smut added gave sound plants free from the disease, and the same pots sown in 1895 would reproduce the disease when artificially smutted, and grew sound plants in one pot. * * * The smut gets on the ovary at flowering time, the grain matures without any sign of being diseased. * * * Believe the spore is embedded beneath the epidermis or skin and is beyond reach of destruction by pickling.

The histological details of the infection were not worked out.

^a Maddox, F. "Experiments at Eastfield." Department of Agriculture, Tasmania, 1895.

^b Maddox, F. "Notes and Results on Agricultural Experiments Carried on Under the Auspices of the Council of Agriculture of Tasmania at Eastfield, Newnham." Launceston, Tasmania, 1897.

Hori,^a in discussing the question whether spores carried into the flowers may cause infection, says:

Mr. S. Wakagawa, of our former branch station at Matsuto, carried out an experiment on this point early in 1897. He introduced the matured spores of *U. tritici* into the flowers of wheat in the same field by means of a forceps. The infected seeds were sown in the ordinary time of the autumn of the same year. In the following year the ears as soon as they appeared were found to be all smutted. Similar experiments made by Mr. K. Yamada gave the same result. Soon afterwards I obtained similar results in flower infection with *U. tritici* and *U. nuda*. Hence I concluded that the spores of those smuts which mature at the flowering time of the host, and may be scattered easily by the wind, will be retained in the inner side of the seed and give rise to the smut disease during the next flowering time of the host plant.

In 1903 Freeman^b described an intraseminal infection of the darnel grass. The fungus which is very commonly found in this plant seldom, if ever, produces spores. It lives in the growing point of the darnel in a manner quite similar to that of the cereal smuts. Instead of forming spores in the ovary, as most smuts do, it lies in wait for the young embryo of the darnel and infects the growing point, thus passing from one generation of darnel to the next, always living in the stem-growing points and neglecting altogether, as far as is at present known, to produce spores. The histological details of this intraseminal infection were shown.

Brefeld,^c in 1903, and Hecke,^d in 1904, working independently and apparently without any knowledge of Maddox's work in Tasmania or Hori's investigations in Japan, again demonstrated the floral infection of the loose smuts of wheat and barley. The histological data of the growing-point infection were added to make the evidence of floral infection complete.

The life history of the loose smuts of wheat and barley may be briefly described as follows: The smut spores in the field are distributed by the wind at the flowering time of the grain plant. They are blown into the spikelets, find their way between the glumes, and come in contact with the young ovary, or stigma. Here they germinate; the germ tube penetrates the ovary wall and the fungus finds its way into the growing point of the embryo. The mycelium then continues to develop until the grain is ripe without giving any external evidence of its presence. It lies dormant inside of the seed until the grain germinates, when it continues to develop with the

^a Bulletin, Imperial Central Agricultural Experiment Station, Japan, vol. 1, No. 2. 1907. [English.]

^b Philosophical Transactions, Royal Society of London, series B, vol. 196, pp. 1-27. 1903.

^c Nachrichten aus dem Klub der Landwirte zu Berlin, No. 466. 1903.

^d Zeitschrift für das Landwirtschaftliche Versuchswesen in Oesterreich. 1904.

seedling, keeping pace with the growing point until the head is formed. It then invades all of the young spikelets and destroys them, replacing them with the smut spores.

The life histories of the loose smuts of barley and wheat thus differ widely from those of the covered smut of barley and the stinking smut, or bunt, of wheat, where the spores are not distributed to any extent at flowering time, but get on the seed either in thrashing, in the bin, or in handling in sacks or in machinery. The spores of the latter smuts are sown together with the grain and germinate at the same time. The fungus then invades the young grain plant as it emerges from the seed, grows along with it until maturity, and forms the smut balls in place of sound grains.

EXPERIMENTS IN LIFE HISTORIES OF LOOSE SMUTS.

In order to test the validity of previous investigations, experiments in inoculations were undertaken at St. Anthony Park, Minn., in 1906 and 1907. The seeds from the inoculated plants in 1906 were planted in 1907, and the 1907 inoculations were tested in 1908.

The inoculations were made in the fields in 1906 and in special plats in 1907. Various methods as described later were employed. In testing the effect of inoculation at different stages of the flower, the following letters were used to designate the condition of the majority of flowers in the spike:

- a—Before the stamens are mature.
- b—At maturity of stamens.
- c—Ovary just commencing to enlarge after fertilization.
- d—Ovary one-third mature size.
- e—Ovary two-thirds mature size.

The use of plus and minus signs serves to indicate intermediate conditions.

After inoculation some heads were covered with paraffin bags or with tissue paper, while others were left uncovered. The seeds obtained were treated before sowing with a solution of 2½ parts of formalin in 1,000 parts of water for two hours in order to insure the prevention of any infection from clinging spores of either loose or covered smut.

Fresh spores from mature smutted heads were always used as inoculating material. The spikelets were prepared for inoculation in some cases by cutting off the glumes near the base of the awns, thus leaving a slight opening between the tips of the glumes. This usually resulted in the loss of a considerable number of seeds where the flowers were in early stages of development. Other heads were left with their awns intact. The smut was applied on some heads by rub-

bing or brushing the outside; on others it was placed directly on the stigma and ovary by opening the glumes (as is done in artificial cross-pollination) and applying the smut with a brush or forceps. In a few cases the heads were moistened by a fine spray of water from an atomizer. A six-rowed barley (Minnesota No. 105) and a bearded spring wheat (Minnesota No. 188) were used as host plants. Both varieties produced in the field tests an average maximum of approximately 3 to 4 per cent of loose smut.

Three loose smuts were used: *Ustilago tritici* (Pers.) Jens. on wheat, *Ustilago nuda* (Jens.) Kell. & Sw. on barley, and *Ustilago lorentziana* Thüm. on wild barley (*Hordeum jubatum*). Cross-inoculations, i. e., from barley to wheat and wild barley, from wheat to barley, and from wild barley to barley, all produced negative results. The three smuts are therefore considered distinct species, incapable of transfer to the other hosts. The covered smut of barley was likewise found unable to produce infection in the flower of barley.

TABLE I.—Results of inoculations of barley with loose smut of barley, St. Anthony Park, Minn.

INOCULATIONS MADE IN 1906; PLANTS MATURED IN 1907.

Method of inoculation.	Stage of flower inoculated.	Plants produced from inoculated seed.		Smutted plants.	
		Number.	Number.	Per cent.	
Spores rubbed on the heads; heads not covered.....	a.....	29	14	49	
	c.....	47	23	49	
	d-e.....	55	0	0	
	e+.....	48	0	0	
Spores rubbed on the heads; heads covered.....	a-b.....	21	4	19	
	c+.....	22	6	*28	
	e+.....	118	0	†0	
Spores placed on ovary; covered.....	a-b.....	14	9	64	

INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.

Spores on ovary; heads covered.....	a-b.....	1	1	100	
	b.....	2	2	100	
	c.....	12	12	100	
	c-d.....	9	8	89	
	d.....	18	9	50	
Glumes cut; spores brushed on heads; heads covered.....	e and e+..	7	0	0	
	b.....	22	1	5	
	c.....	40	2	5	
	c-d.....	18	0	0	
	d.....	14	1	7	
Glumes not cut; spores brushed on heads; heads covered.....	d-e.....	30	1	3	
	c.....	65	1	1.5	
Glumes not cut, spores brushed on heads; heads not covered.....	a.....	4	0	0	
	a-b.....	6	0	0	
	b.....	16	0	0	
	c-d.....	5	0	0	
Glumes cut; spores brushed on heads; heads not covered.....	a.....	29	0	0	
	b.....	26	0	0	
	b-c.....	70	1	1.4	

* Heads sprayed with water when inoculated.

† Part (37 plants) sprayed with water when inoculated.

TABLE II.—*Summary of Table I, showing the effect of the stage of anthesis on infection with loose smut.*

INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.

Stage of flower at inoculation.	Plants produced from inoculated seeds.	Smutted plants.		Partially smutted plants.	Healthy heads in partially smutted plants.
	Number.	Number.	Per cent.	Number.	Per cent.
a and a-b.....	64	27	42	22	35
a and c+.....	69	29	42	6	
d-e.....	55	0	0		
e+.....	166	0	0		

INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.

a to a-b.....	40	1	2.5		
b to b-c.....	136	4	3.0	1	10
c to c-d.....	149	23	15.0	4	30
d to d-e.....	62	11	17.0		
e+.....	7	0	0		

TABLE III.—*Results of inoculations of wheat with loose smut of wheat, St. Anthony Park, Minn.*

INOCULATIONS MADE IN 1906; PLANTS MATURED IN 1907.

Method of inoculation.	Stage of flower inoculated.	Smutted plants.		
		Plants produced from inoculated seed.		
		Number.	Number.	Per cent.
Spores placed on ovary; heads covered.....	c?.....	31	8	26
Spores rubbed on heads; heads covered.....	c?.....	97	10	10

INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.

Spores placed on ovary; heads covered.....	b-c.....	22	7	32
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In 1906 the inoculations recorded in Tables I and II, except that on August 11, were made on July 10 and 11 and the seeds planted May 11, 1907; in 1907 they were made on July 10 and 23 and the seeds planted April 23, 1908.

The 1906 inoculations recorded in Table III were made on July 6 and the seeds planted on May 13, 1907; the 1907 inoculations (Table III) were made on July 23 and 25 and the seeds planted on April 16, 1908.

The results as shown in these tables establish clearly the floral or intraseminal infection of the loose smuts of barley and wheat in this country. Inoculation in the flower produced in some heads 100 per cent of infection.

On account of the variation in the stage of flowering found in almost any head of wheat or barley, the stage designated in the table

is to be interpreted as the average in that head. A common condition illustrating this variability is the following: In many heads of barley examined on July 11, 1907, stage *d* prevailed at the center of the head and stage *c* at the bottom. At the tip the flowers were for the most part slightly in advance of the base, i. e., *c-d*. The optimum time for infection is the full flowering period, viz, stage *c*. Success is common in the earlier stages, even when the stamens are green (*a*). Infection seldom, if ever, takes place in stage *e*, i. e., when the ovary is about two-thirds its natural size. The partial successes in stages *d-e* are undoubtedly due to the *d* spikelets. It may be concluded that inoculation succeeds best just after fertilization of the egg cells, when the embryo has commenced to grow, as shown in the enlargement of the ovary. This agrees with Freeman's results with darnel, where infection took place as soon as the embryo had developed the "anlage" of a stem-growing plant.

At stage *e* and beyond, either the epidermis of the ovary wall or the newly formed aleurone layer is perhaps impenetrable to the germ tubes. The stigma, moreover, has dried and probably can not transmit the germ tube. The conditions previous to stage *c* present interesting data especially in the 1906 inoculations (Tables I and II). Here a striking difference is seen between the effects of inoculation on stage *c* and the earlier stages. (See Table II.) In the former every seed inoculated produced completely smutted plants, i. e., every head was smutted. In the latter 22 out of 27 plants were only partially smutted, and the average number of sound heads was 35 per cent of the total number. It is seen that this result was not duplicated in the 1907 inoculations, where *c* stages exhibited a fairly large number of partially smutted plants (4 out of 16), with 30 per cent of sound heads. Whether this escape of heads in a smutted plant is due to the initial condition of the flowers at the time of inoculation, to the accidental escape of lateral branches in the subsequent growth, or to weather conditions inimical to the best development of the fungus can not be stated until the histological details of the infection and subsequent development are fully understood.

In accordance with what would be expected, the most efficient method of inoculation is that of placing the smut directly on the stigma and ovary, although the rubbing method is also efficient, producing 49 per cent in some cases. The rubbing tests were more successful in 1906 than in 1907, as a result, perhaps, of different weather conditions at the time of inoculation. The season of 1907 was abnormally dry. This may have prevented the spores from being washed into the flower, or the moisture may have been insufficient for spore germination. Covering the heads after inoculation does not seem to be essential.

In spite of the remarkably close pollination in barley the glumes may often be found open one-sixteenth of an inch (and in some cases even more) at the time of maturity of the stamens. They are, of course, forced apart a little later to allow the stamens to be extruded. It is undoubtedly during these open periods that the smut spores gain entrance to the flower, perhaps most frequently at the earlier one. That the opening is as wide in all flowers as that stated above is extremely improbable. Varietal differences based on the opening habits are to be expected, though up to the present none have been observed. In addition, the state of the weather during flowering time in a field must exert a great influence on distribution. The results of the following test are probably explainable only on the basis of un-

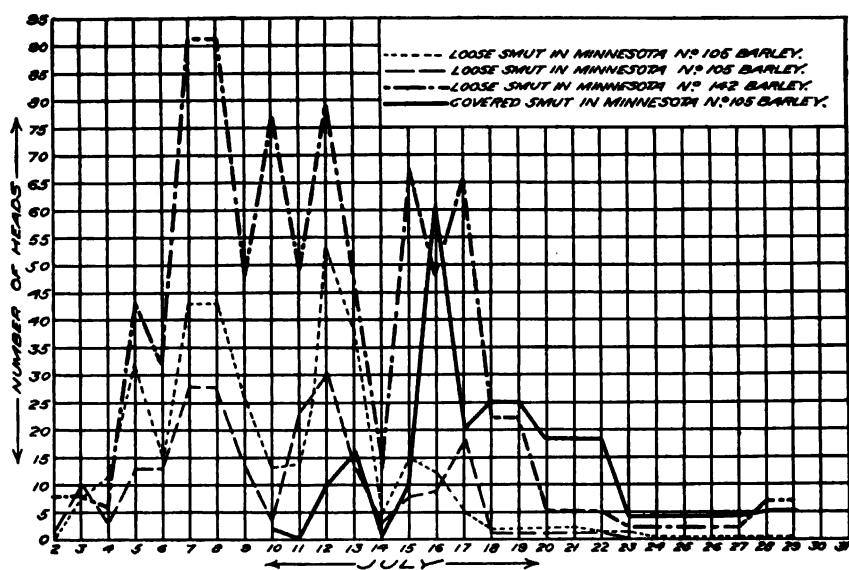


FIG. 1.—Diagram showing the daily record of barley smut at St. Anthony Park, Minn., in 1907.

favorable weather conditions. Eighty-two seeds were obtained in 1907 from wheat heads in which the glumes had been cut as previously described. These were then left exposed to natural infection. Less than 2 per cent of loose smut resulted, while 2 to 5 per cent was found among uncut control plants in the same plats.

The flowering period in a pure variety is, of course, fairly uniform. Stages *c* to *d* were quite general in the fields at St. Anthony Park in the barley varieties known as Minnesota Nos. 105 and 142 on July 10 and 11, 1907. Figure 1 shows the number of smutted heads picked from several one-fortieth-acre plats of barley which were rogued carefully each day. There were two plats of Minnesota No. 105 and one plat of Minnesota No. 142. One plat of Minnesota No. 105 con-

tained covered smut, as shown in the diagram, while the other, which had been treated with formalin, had none. Minnesota No. 142 barley did not have any covered smut. The approximate median date of the maximum period of loose smut in 1907 was July 10 in Minnesota No. 105 and July 12 in Minnesota No. 142. The corresponding date for the covered smut was July 18, approximately one week later.

It will be seen that the full flowering period in 1907, viz, July 10 and 11, fell exactly on the median date of maximum smut. The later appearance of covered smut is explained in its spore habit of clinging to the grain, as do the spores of the stinking smut of wheat. The effective formalin treatment previously mentioned is strong evidence that this is the case.

The mere fact of close proximity of a head of barley or wheat to a smutted head does not necessarily insure infection. Heads of barley (Minnesota No. 105) growing close to smutted heads in 1906 were selected, and 324 plants from this seed matured in 1907 with an average of 2.2 per cent of smutted plants—less than the field average for this variety in the same year.

The phenomena of partially smutted heads introduce interesting possibilities. In such heads on wheat, for instance, various conditions may be found. In some spikelets observed in 1907 only the glumes escaped the smut; in some, the ovary alone was attacked, the ovary wall remaining apparently uninjured; in others, no smut appeared, but the ovary was aborted, and in still others apparently sound grains were produced. In partially smutted heads the upper spikelets of the head most commonly escape. Occasionally, however, the middle spikelets are sound while the spikelets above and below are smutted. No cases have been observed where the basal spikelets escape the smut. In regard to partially smutted heads the following questions arise: Do the sound grains entirely escape infection as the head develops or do they contain the fungus in a dormant stage after an ineffectual attempt to form spores has been made? The possibility of the latter condition is actually paralleled in the case of the fungus of the darnel, where the parasite regularly gets into the seeds and infects the young embryos, but does not form spores. To test this possibility sound seeds from smutted heads were collected in 1906 and 1907 and planted during the following years. To avoid external infection these were treated with formalin before planting. From such seed from the 1906 crop 98 plants of barley developed 2 per cent of smut in 1907, and 51 plants from seed from the 1907 crop developed 2 per cent of smut in 1908. In each case the amount of smut did not reach the average (3 to 4 per cent) in the field crop. It seems clear, therefore, that the sound grains in a smutted head escaped infection as far as

the mycelium inside of the infected head is concerned. Similar results were obtained with loose smut of oats.

INFLUENCE OF TIME OF PLANTING ON LOOSE SMUT.

In Table IV are shown the results obtained by planting spring wheat and barley at different times to determine what effect the time of planting may have on the development of the smut. As infection took place in 1906, this is merely a test of the development of the fungus in 1907 in plants grown from the already infected seed.

TABLE IV.—*Influence of time of planting on loose smuts of barley and wheat, St. Anthony Park, Minn., 1907.*

Date of planting.	Barley, Minnesota No. 105.		Barley, Minnesota No. 142.		Wheat, a, Minnesota No. 188.		Wheat, b, Minnesota No. 188.	
	Number of heads.	Smut.	Number of heads.	Smut.	Number of heads.	Smut.	Number of heads.	Smut.
		Per cent.		Per cent.		Per cent.		Per cent.
Apr. 23			759	5.53			981	1.21
25			901	5.87			1,038	1.54
26	587	1.36			761	1.31		
May 6	515	.58	837	6.81	672	1.33	887	2.14
7	517	1.35	1,097	5.64	748	1.81	1,002	.89
8	788	1.65	774	5.42	831	1.56	933	1.50
9	324	2.79	743	6.46	844	.94	848	.94
10	392	1.78	551	4.53	324	2.77	751	1.33
11	281	1.78	740	4.58	517	2.70	1,025	2.14
13	325	.92	591	7.10	491	4.07	611	1.47
14	338	1.47			517	2.51		
15	110	2.72	897	6.35	581	1.37	964	3.24
16	446	1.79	695	5.46	598	3.17	740	2.43
17	359	1.39	940	4.04	745	2.68	882	1.02
20	217	3.68	665	5.56	622	2.41	558	1.07
22	249	2.81	662	5.13	545	2.56	611	1.47
24	342	1.16	843	3.91	556	3.05	553	1.44
27	191	3.15	679	3.94	441	3.40	428	2.33
29	240	1.20	712	5.05	362	1.93	351	1.76
31	262	1.14	571	3.46	335	2.08	426	1.40
June 3	200	3.5	516	2.32	252	1.98	276	.72
5	173	1.73	742	2.56	252	.79	266	1.12
7	259	.38	306	2.74	227	.44	207	.48

Barley (Minnesota No. 105) and wheat, *a* (Minnesota No. 188), were planted in a dry, sandy soil with good drainage, while barley (Minnesota No. 142) and wheat, *b* (Minnesota No. 188), were planted in a fairly heavy, low-lying, moist soil. The time of planting had no marked effect on the amount of smut. Wheat on the sandy soil contained on an average slightly more smut than that on the heavier, low-lying soil, but the difference was not great. The latest plantings showed a slight decrease. This decrease, however, is not consistent, and is certainly too small to be of practical importance, since comparatively few heads filled and the plants were badly stunted. Similar results with the same wheat and barley (Minnesota No. 188 and Minnesota No. 105, respectively) planted at intervals of about four to six days, from April 22 to May 28, were obtained in 1908.

It may be concluded, therefore, that the time of planting within the range of dates attempted does not affect to any appreciable de-

gree the development of the loose-smut fungus in the host plant as far as spring wheats and spring barleys are concerned.

In regard to winter wheats and winter barleys the case may be different. The following experiment was performed by Mr. A. H. Leidigh, at Amarillo, Tex., in 1905 and 1906, with Tennessee Winter barley. Plantings were made from the same bulk of seed on September 21, October 12, and November 11, 1905. In 1906 the three plantings contained very different amounts of smut. The earliest, that of September 21, developed 10 to 12 per cent of smut; the October 12 planting (about the usual time of planting for that section of the country) developed 22 to 25 per cent of smut, and the November 11 planting showed less than 1 per cent. In the same season, 1906, barley from the same bulk of seed developed at Chillicothe, Tex., about 27 per cent of smut. There seems to be no doubt that the time of planting had in this case a very considerable effect on the amount of smut. Results exactly similar to these were obtained with Japanese wheat and barley by Hori,^a who says, in part:

It is a peculiar phenomenon that if the seeds are sown early in the season the smut proportionally increases, and vice versa. * * * In consequence the smut is comparatively rare on wheat and barley cultivated in the rice fields, because the labor of harvesting the rice, draining, plowing, and drilling delays the sowing at least one to one and a half months. That fact is no doubt due to the difference between the germinating temperature of the smut spore and that of the seeds.

It is thus seen that the results in Japan were exactly similar to those obtained by Mr. Leidigh, at Amarillo, since the Japanese wheats and barleys were winter varieties. In general, the explanation given by Hori seems probably correct, namely, that the mycelium of the loose smut requires a higher minimum temperature for germination and growth than does the wheat or barley seed. The fact that the spring wheats and barleys do not show a decrease on the earliest dates in the experiment outlined in Table IV is possibly explained by the supposition that the required temperature difference did not exist under spring grain conditions in that locality.

TREATMENTS FOR LOOSE SMUTS.

HISTORICAL REVIEW OF TREATMENTS PREVIOUSLY APPLIED.

All previous experiments with these smuts demonstrate that ordinary seed treatment is of no avail. Jensen ^b (1887-1889) devised

^a Bulletin of the Imperial Central Agricultural Experiment Station, vol. 1, No. 2, pp. 163-176. 1907. [English.]

^b Jensen, J. L. Nye Undersogelser og Forsog over Kornsorternes Brands, 1887, p. 15; Propagation and Prevention of Smut in Oats and Barley. Journal of the Royal Agricultural Society of England, vol. 24, second series, part 2; Le Charbon des Cereales, Copenhagen, July, 1889.

what is known as the modified hot-water treatment, in which soaking of barley in cold water for eight hours, followed by treatment in hot water at 127° F. for five minutes, destroyed the smut. Kellerman and Swingle^a cite the experiments made in Denmark by Jensen and add: "We therefore strongly recommend his latest form of the treatment, which is as follows: Soak the barley for four hours in cold water and then let it stand four hours longer in a wet sack. Finally dip and drain, as directed in the treatment for oat smut, for five minutes in water of a temperature of 126°-128° F., after which dry and plant as in case of oats." No recommendation of the modified hot-water treatment for the prevention of loose smut of wheat is made in this or in Jensen's reports. Kellerman^b records numerous trials where the wheat was treated for five minutes at various temperatures after being "previously soaked." He concludes, however, that "no grounds, based on actual experiments, appear to exist for recommending the treatment of the seed with hot water or any other fungicide."

Swingle,^c basing his recommendations on experiments in Kansas planned by Kellerman and Swingle, carried out by Swingle and reported by Kellerman in 1891, in 1894 first recommended a modified hot-water treatment for loose smut in wheat as follows:

Grain must be soaked four hours in cold water, then set away about four hours more in wet sacks, and finally treated as directed above, but only for five minutes, at 132° F. In planting use one-half more seed per acre to compensate for seed killed by the treatment. For preventing both of the smuts affecting barley the grain should be soaked as directed above and treated five minutes at 130° F., 2 degrees lower than for wheat. * * * It [loose smut of wheat] can, however, be combated by treating enough wheat to furnish seed for the following year, and this should be done when any considerable per cent of the crop is affected.^d

In 1898 the same author made the same recommendations for preventing loose smuts of wheat and barley, but for the barley treatment added that "this treatment does not injure the seed."^e

Maddox,^f in 1896, found that by carefully picking out the loose smut heads in wheat for two years in succession in a 4-rod plat seed was obtained for a half acre which was almost entirely clean of smut.

^a Kansas Agricultural Experiment Station, Second Annual Report, 1889, pp. 283-284.

^b Bulletin 22. Kansas Agricultural Experiment Station, 1891.

^c Yearbook of the United States Department of Agriculture, 1894, p. 417.

^d Yearbook of the United States Department of Agriculture, 1894, p. 412.

^e Farmers' Bulletin 75. United States Department of Agriculture, p. 14.

^f Maddox, F. Loc. cit.

Moore,^a working on loose smut of barley in Wisconsin, obtained favorable results by soaking seed for twelve hours in cold water, draining one hour, and treating for ten minutes in water at 130° F.

Hori^b was likewise able to prevent loose smuts by soaking the seed for seven hours in cold water, immersing it for a few minutes in water at 122° F. (50° C.), and finally treating it in water at 131° F. (55° C.) for five minutes.

EXPERIMENTS IN THE TREATMENT OF LOOSE SMUTS.

Jensen's treatment for loose smut was devised without knowledge of the life history of the smut. Since there seemed to be a possibility of further perfecting it, experiments were undertaken chiefly with this method.

EFFECT OF TREATMENT ON THE GERMINATION OF WHEAT AND BARLEY.

Preliminary tests were made at Washington, D. C., in February, 1907, of the effect on barley and wheat of soaking, followed by hot-water treatment. The germination tests were made in the Seed Laboratory of the Bureau of Plant Industry by W. L. Goss. Tables V and VI present the practical results of these tests, showing the duration of the soaking in cold water and the highest temperatures of hot water used, with the length of time of treatment, which resulted in a seed germination of 60 per cent or more. The results in all cases show a very marked decrease in germination when the temperatures are raised above those given in the table. Small quantities of seed were soaked in beakers for the specified time, then quickly drained, placed in wire baskets and immersed in a large tub of hot water in which the recorded temperatures were accurately maintained. The periods of treatment in hot water were 5, 10, and 15 minutes.

The percentages of the germination after treatment are also given. Each table is arranged to show (1) the highest temperature and (2) the longest duration of the hot-water treatments which gave a germination of 60 per cent or more. The control germinations of unsoaked seeds without any hot-water treatment were in all cases above 90 per cent.

^a Wisconsin Agricultural Experiment Station, 23d Annual Report, 1906, pp. 270-274.

^b Loc. cit.

TABLE V.—*Effect on the germination of wheat (Spring Wheat Minnesota No. 169) of treatment with hot water preceded by a soaking in cold water, showing the highest temperature and the time limits with various treatments, Washington, D. C., February, 1907.*

ARRANGED ACCORDING TO TEMPERATURES.

Period of soaking in cold water.	Temperature of hot water (maximum).	Duration of hot-water treatment with little or no injury to germination.
<i>Hours.</i>	<i>°C.</i>	<i>Minutes.</i>
12-13.....	52.0	5, 10, or 15.
12-13.....	54.4	5.
6-7.....	52.0	5, 10, or 15.
6-7.....	54.0	5, 10 (70 per cent), or 15 (65 per cent).
6-7.....	56.0	5.
4-5.....	52.0	5, 10, or 15.
4-5.....	54.0	5, 10, or 15 (60 per cent).
4-5.....	56.0	5 (73 per cent).

ARRANGED ACCORDING TO DURATION OF TREATMENT.

Period of soaking in cold water.	Duration of hot-water treatment.	Temperature of hot-water (maximum).	Germination.
<i>Hours.</i>	<i>Minutes.</i>	<i>°C.</i>	<i>Per cent.</i>
12.....	15	52.0	81
12.....	10	52.0	86
12.....	5	54.4	84
6-7.....	15	54.0	65
6-7.....	10	54.0	70
6-7.....	5	56.0	73
4-5.....	15	54.0	60
4-5.....	10	54.0	86
4-5.....	5	56.0	73

TABLE VI.—*Effect on the germination of three six-rowed varieties of barley (Oderbrucker, G. I. No. 537; Mansury, G. I. No. 170; Kitzing, G. I. No. 189) of treatment with hot water preceded by a soaking in cold water.*

ARRANGED ACCORDING TO TEMPERATURES.

Period of soaking in cold water.	Temperature of hot water (maximum).	Duration of hot-water treatment with little or no injury to germination.
<i>Hours.</i>	<i>°C.</i>	<i>Minutes.</i>
12-13.....	52	5, 10, or 15 (Kitzing).
12-13.....	54.4	5 (Kitzing).
7-8.....	52	5, 10, or 15 (except 15 minutes in Kitzing).
7-8.....	54	5 or 10 (except 10 minutes in Kitzing).
7-8.....	56	5 (except in Kitzing).
4-6.....	52	5, 10, or 15.
4-6.....	54	5 or 10 (except Kitzing), and 15 in Oderbrucker.
4-6.....	56	5 (except Kitzing).
No soaking.	57	5, 10, or 15.
Do.....	58	5 or 10.

TABLE VI.—*Effect on the germination of three six-rowed varieties of barley, etc.—Continued.*

ARRANGED ACCORDING TO DURATION OF TREATMENT.

(O, Oderbrucker ; M, Mansury ; K, Kitzing.)

Period of soaking in hot water.	Duration of hot-water treatment.	Temperature of hot water (maximum).	Germination.
<i>Hours.</i>	<i>Minutes.</i>	<i>°C.</i>	<i>Per cent.</i>
12-13.....	15	52	K-88.
12-13.....	10	52	K-97.
12-13.....	5	54	K-70.
7-8.....	15	52	O-92, M-86, K-48.
7-8.....	10	54	O-77, M-82, K-14.
7-8.....	5	56	O-85, M-71, K-15.
4-6.....	15	54	O-72, M-32, K-25.
4-6.....	15	52	O-90, M-98, K-68.
4-6.....	10	54	O-92, M-97, K-54.
4-6.....	5	56	O-84, M-71, K-24.
No soaking.	15	57	O-98, M-99.
Do.....	10	58*	O-96, M-96.
Do.....	5	58*	O-95, M-97.

* Probably not the extreme limit ; no higher temperature was tried.

All of the seed used was good fresh seed of the 1905 and 1906 crops, with the possible exception of the Kitzing barley, which, although the control gave 96 per cent of germination, looked old and badly weathered. The inability of the Kitzing barley to endure as severe treatments as the other barleys may have been due to this fact. In general, therefore, the treatments mentioned were accepted as the maximum in severity which would prove at all practicable.

Experiments were then undertaken based on the results recorded in Tables V and VI. These experiments with Jensen's modified hot-water treatment are shown in Tables VII to XII, inclusive. The treatment in each case is designated by three figures—e. g., 5-5-56—in which the first figure gives the number of hours of soaking in cold water, the second the number of minutes of soaking in hot water, and the third the temperature of the hot water in degrees centigrade. Treatment 5-5-56 is therefore a five-hour soaking in cold water, followed by a five-minute soaking in hot water at 56° C. Since small quantities of seed were used, a draining of only a few minutes was deemed necessary. The amount of seed was so small compared with the bulk of hot water that the temperature of the latter was seldom affected even slightly. The actual duration of soaking in some cases varied slightly from that given in the tables, but never to the extent of one hour's difference (except where noted). These variations, amounting mostly to fifteen and twenty minutes, are without doubt negligible. The duration of the hot-water treatments is in every case correct within a few seconds.

The temperature record (except when otherwise noted) is correct within 0.5° C. In all tests and treatments the centigrade scale has been used. In many cases the temperature was held absolutely constant throughout the treatment. As the tests were made for the most part at intervals of 2 degrees, the slight variations of less than 0.5° C. are likewise negligible, especially when the practical application of the results is considered. The laboratory germination tests (made by W. L. Goss in the Seed Laboratory of the Bureau of Plant Industry) are given in percentages. The field germination in most cases is estimated as excellent (E), good (G), fair (F), poor (P), or very poor (VP). In Table X the field germination is accurately computed and given in percentages.

Some seed was treated at Washington, D. C., during the winter or early spring months and kept thoroughly dry after treatment until it was planted at St. Anthony Park, Minn. Other seed was treated at St. Anthony Park just before planting and was not allowed to dry completely before seeding, which usually took place on the same or the following day. In 1907 the seeding was interrupted by snowstorms, and the treated seed was then kept moist and cool for several days in a tin box, which was packed in sawdust in an icehouse, so that no germination took place before seeding. The varieties used were those which had shown large amounts of smut at the Minnesota Agricultural Experiment Station in previous years. No actual counting tests of the amounts of smut had previously been made, and when such tests were made in 1907 the standards of percentages used in the Minnesota station's previous records were found to be too high, so that they could be used only in general comparisons. Particulars as to the dates of planting, the germination in the field, and the details of smut pickings have been omitted from the tables. The seeds were in all cases planted at the usual time for these grains at St. Anthony Park.

HOT-WATER TREATMENT OF BARLEY.

The results of the experiments with barley in 1907 are recorded in Table VII. The barleys used were Minnesota Nos. 142, 144, and 145. In 1906 No. 142 contained the most smut; Nos. 144 and 145 were affected about equally and had considerably less than No. 142. In 1907 field plats of No. 142, according to careful estimates, contained 4.62 per cent of smut.

TABLE VII.—*Results of experiments with Jensen's modified hot-water treatment on barley, at Washington, D. C., and at St. Anthony Park, Minn., 1907.*

Treatment.	Minnesota No. 142.*				Minnesota No. 144.*				Minnesota No. 145.*				Minnesota No. 142.†			
	in Germination laboratory.	in Germination field.	Number of heads.	Smut.	in Germination laboratory.	in Germination field.	Number of heads.	Smut.	in Germination laboratory.	in Germination field.	Number of heads.	Smut.	in Germination laboratory.	in Germination field.	Number of heads.	Smut.
Control....	97	E	332	P. ct.	94	E	512	P. ct.	98	E	486	P. ct.	97	E	1,801	P. ct.
0-10-58....	93	E	469	6.95	91	E	360	0.78	90	E	495	7.40	E	E	1,298	3.65
0-15-56....	93	E	444	5.75	92	E	494	1.94	96	E	668	6.87	E	E	1,517	4.77
5-5-56....	94	F	323	7.20	86	F	259	0	96	F	462	9.28	E	E	844	3.75
5-10-54....	96	F	426	2.47	92	F	292	.38	96	F	274	.43	E	G	1,295	.14
5-15-52....	90	F	467	.93	88	E	357	.34	96	E	823	0	E	E	1,337	.07
7-5-54....	92	E	4.2	0	72	E	295	0	93	E	507	0	E	E	1,279	0
7-10-54....	52	F	205	0	62	F	174	0	90	G	421	0	E	G	992	0
7-15-52....	87	G	303	0	78	G	280	0	94	G	366	0	E	F	1,186	0
12-5-54....													E	F	1,204	0
12-10-54....													E	F	568	0
12-15-52....													E	E	1,178	0
15-5-54....	63	P	230	0	74	P	172	0	88	P	351	0				
15-10-54....	12	VP	77	0	12	VP	34	0	56	VP	274	0				
15-15-52....	60	P	458	0	72	P	130	0	88	F	344	0				
24-5-54....		P	0											F	861	0
24-10-52....		F	0											G	1,242	0
24-15-52....		P	0											G	1,091	0

* Treated at Washington, D. C., March 15, 1907.

† Treated at St. Anthony Park, Minn., about May 4, 1907, before sowing, but thoroughly dried before planting.

The control and the "no-soak" treatment gave plants which matured two to three days earlier than any of the other treatments. Soaking more than twelve hours, even when followed by mild treatments (ten to fifteen minutes at 52° C.), impaired germination decidedly.

Temperatures above 54° C., e. g., 56° C. for five minutes, did not prevent all of the smut but impaired germination both in the dried and freshly treated seeds. The indicated treatment lies therefore in a previous soaking of between four and twelve hours, a hot-water treatment of from five to fifteen minutes, and temperatures of 52° to 54° C. A treatment of more than five minutes at 54° C., after soaking from seven to twelve hours, injured germination in most cases.

The most successful treatment, both in the prevention of smut and in unimpaired germination, was a soaking of from five to seven hours in cold water followed by a fifteen-minute soak in hot water at 52° C. An even longer soak, e. g., twelve hours, did no damage to germination in freshly treated seed.

Drying after treatment was apparently not injurious to the smut-preventing power of the treatment and did not seriously affect the germination.

Extensive experiments similar to those recorded in 1907 were undertaken in 1908 to test these results. Unfortunately the barley used (Minnesota No. 195), though recorded as having considerable smut in 1907, produced almost no smut in 1908, the control giving no smut. The results were therefore useful only in connection with the data on germination, and these were in accord with those shown in Table VII. Experiments in regard to germination after the various treatments made with Boehme's white-bearded hull-less barley (G. I. No. 533) gave similar results throughout.

The success of Jensen's method lies without doubt in the soaking in cold water. Soaked seed probably allows a more uniform conduction of heat through the embryo than dry seed. There is, however, another effect which is, perhaps, of even greater importance. Soaking may stimulate to activity the contained smut mycelium. It seems possible, therefore, that Jensen's treatment on the one hand is efficient merely because of the increased conductivity brought about by soaking and on the other because it stimulates the mycelium to growth, in which condition it is more easily injured by the hot-water treatment. In order to throw light on this point, and also to devise, if possible, a method less injurious to the seed than Jensen's treatment the following experiment was undertaken in 1908: Some barley was soaked in ice water at a temperature of 3° C., and some in cold water at ordinary temperatures, viz, 20° C., for comparison. The results are recorded in Table VIII.

TABLE VIII.—*Results of experiments with Jensen's modified hot-water treatment on barley (Minnesota No. 142), St. Anthony Park, Minn., 1908.*

Treatment.	Seed soaked in ice water (3° C.).			Seed soaked in cold water (20° C.).		
	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
			<i>Per cent.</i>			<i>Per cent.</i>
Control.....	E	1,453	2.0	E	1,453	2
6-5-52.....	E	976	2.5	E	*1,000	0
6-10-52.....	E	996	2.2	E	*1,000	0
6-15-52.....	E	941	1.0	E	*1,000	0
6-5-54.....	E	1,115	.9	E	*1,000	0
6-10-54.....	E	844	1.3	F	†1,000	0
6-15-54.....				VP	†1,000	0
6-5-56.....	E	839	1.3	VP	†1,000	0
6-10-56.....	P	671	.4	0		
6-15-56.....	VP			0		
6-5-58.....	VP	521	.7	0		

* Approximate figures.

† Less than 1,000.

The cold-water soaking treatments confirm those of 1907 in regard to smut prevention and germination. The ice-water soaking, however, is seen to be entirely inefficient against the smut and therefore

valueless. This is probably best explained by the inability of the low-temperature soaking to stimulate the dormant fungous mycelium to any considerable growth. If this is true, the temperatures which after the cold-water soaking are sufficient to kill the growing mycelium without seriously affecting the germinating embryo have little or no effect upon the almost dormant mycelium after the ice-water soaking. A similar explanation might also be given for the inability of the hot-water treatment without any previous soaking (see Table VII) to prevent smut. In the experiments on wheat (Table X), ice-water soakings for twelve and thirteen hours were efficient in smut prevention, as were also soakings of six hours followed by temperatures of 56° C. or more, but in the latter case germination was seriously impaired by most of the treatments. These facts suggest, furthermore, that the soakings in ice water for six hours stimulate the mycelium, but to such a slight degree that it requires high and injurious temperatures (56° C.) to destroy the smut in its almost dormant stage.

HOT-WATER TREATMENT OF WHEAT.

The results of experiments with wheat are presented in Table IX (1907) and Table X (1908). A bearded, hard spring wheat (Minnesota No. 188) was used in all the experiments. This variety developed considerable smut in 1906. In 1907 counts made in the fields showed in general 3 to 4 per cent of smut, and in 1908 similar counts showed as much as 5 per cent.

TABLE IX.—Results of experiments with Jensen's modified hot-water treatment on wheat (Minnesota No. 188), St. Anthony Park, Minn., 1907.

Treatment.	Planted soon after treatment.			Seed dried after treatment.		
	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
			<i>Per cent.</i>			<i>Per cent.</i>
Control.....		2,856	1.29		2,856	1.29
0-10-58.....	E	2,060	1.35	G	1,752	2.16
0-15-58.....	G	1,793	1.72	F	1,596	1.25
5-5-58.....	E	2,357	0	E	2,509	0
5-10-54.....	E	2,450	0	F	2,356	0
5-15-54.....	E	1,841	0	E	1,716	0
7-5-58.....	E	2,160	0	E	1,414	0
7-10-54.....	E	2,306	0	E	2,102	0
7-15-54.....	E	1,873	0	E	1,767	0
13-5-54.....	E	2,454	0	E	1,998	*0
13-10-52.....	E	2,416	0	E	2,383	*0
13-15-52.....	F	2,444	0	E	2,050	*0
24-5-54.....	G	1,392	0	F	1,164	.08
24-10-52.....	G	1,661	0	F	1,422	.14
24-15-52.....	F	1,517	0	F	554	0

* Soaked in cold water for twelve hours.

TABLE X.—*Results of experiments with Jensen's modified hot-water treatment on wheat (Minnesota No. 188) at Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Seed soaked in ice water (0.5°-1.5° C.).*				Seed soaked in cold water (15° C.-17° C.).*				Seed soaked in ice water (3° C.).†			Seed soaked in cold water (20° C.).†		
	Germination in laboratory.	Germination in field.	Number of plants.	Smut.	Germination in laboratory.	Germination in field.	Number of plants.	Smut.	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
Control	P. ct. 92.5	P. ct. 68	135	2.96	P. ct. 92.5	P. ct. 68	135	2.96	P. ct. E	1,257	4.6	P. ct. E	1,257	4.6
5-5-52	93.0	80	159	3.12	94.5	81	162	.61	E	1,771	2.9	E	1,567	.1
5-10-52	92.0	82	163	2.45	95.0	85	169	0.	E	1,333	3.1	E	1,200+	0
5-15-52	94.5	79	158	3.16	95.0	79	158	0	E	1,572	3.2	E	1,200+	0
5-5-54	91.0	83	166	3.01	93.0	82	163	0	E	1,587	1.2	E	1,200+	0
5-10-54	85.5	73	145	2.75	92.5	75	150	0	E	1,368		E	1,200+	0
5-15-54	80.5	71	141	.70	80.0	66	131	0	E	1,401	.3	G	1,200+	0
6-5-56	92.5	74	147	2.72	81.5	66	132	0	E	1,298	.3	G	1,000-	0
6-10-56**	71.5	70	139	.71	30.0	40	80	0	G	1,405	.4	VP	1,000-	0
6-15-56	36.5	50	99	0	3.0	7	13	0	F	794	0	VP		
6-5-58	61.0	50	100	0	2.5				P	1,040	1.0	0		
6-10-58	8.5	13	25	0	0									
6-15-58	1.0	0		0	0									
12-5-52††	91.0	81	162	1.85	92.5	82	163	0						
12-10-52	96.5	80	160	1.25	89.5	79	158	0						
12-15-52	87.5	78	155	0	88.5	74	147	0						
12-5-54	89.0	80	160	0	89.5	69	138	0						
12-10-54	82.5	74	148	0	80.5	58	116	0						
12-15-54	77.5	66	131	0	72.0	49	98	0						
13-5-56	73.5	51	101	0	65.0	22	44	0						
13-10-56	15.0	32	63	0	0									
13-15-56	1.0	7	13	0	0									
13-5-58	4.5			0	0									
13-10-58	0			0	0									
13-15-58	0			0	0									

* Treated at Washington, D. C., January 29, 1908; planted at St. Anthony Park, Minn., April 15 and 16, 1908.

† Treated at St. Anthony Park April 17, 1908; planted at St. Anthony Park April 18, 1908.

** Average, 55.4° C.

†† 51°-51.4° C.

The results of the treatments shown in Tables IX and X are seen to be similar to those with barley. Wheat, however, shows ability to endure longer soaking and slightly higher temperatures. Treatments of ten minutes at 54° C., even after a soaking of twelve hours, gave good results both in germination and smut prevention.

The most desirable treatment is apparently the following: Soaking for five to seven hours in cold water followed by immersion in hot water at 54° C. for ten minutes.

The ice-water treatments likewise gave results similar to those of barley—i. e., they were inefficient against the smut except at high temperatures injurious to germination.

EFFECT ON GERMINATION OF DRYING TREATED SEED.

In the experiments of 1908 with both wheat and barley, data on the effect of the drying of the treated seed on germination were obtained. Part of the seed was treated January 29, and tests for germination were made in the Seed Laboratory on the following dates: January 31. February 6 and 20, and March 5 and 19. The re-

mainder of the seed was treated February 4, 1908, and laboratory tests were made February 3, 13, and 20, and March 5 and 19. The seed was planted April 16. The tests were made from seed from both ice-water and cold-water soakings followed by the hot-water treatments. The results with both barley and wheat and from both treatments were similar. In all treatments which were not injurious to germination the tests at the different dates gave practically the same results (fig. 2, curves B and F). Where the treatment was injurious,

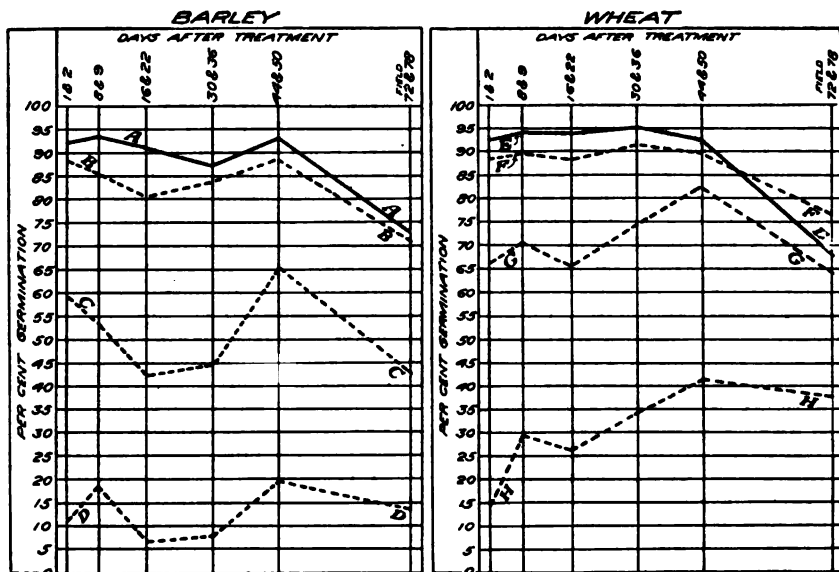


FIG. 2.—Diagram showing the effect on germination of drying the seed of barley (Minnesota No. 195) and wheat (Minnesota No. 188) after the application of Jensen's modified hot-water treatment for loose smut. The treatments were made January 29 and February 4, 1908, at Washington, D. C. The germination tests were made the number of days indicated after treatment. The first figures (1, 8, 16, etc.) give the dates after the treatment of February 4; the second figures (2, 9, 22, etc.), dates after that of January 29. The seed was planted at St. Anthony Park, Minn., April 16, 1908. A, barley, control (no treatment); B, barley, average of 19 tests, initial test between 100 and 76 per cent, inclusive; C, barley, average of 6 tests, initial test between 75 and 51 per cent, inclusive; D, barley, average of 11 tests, initial test less than 51 per cent; E, wheat, control (no treatment); F, wheat, average of 20 tests, initial test between 100 and 76 per cent, inclusive; G, wheat, average of 5 tests, initial test between 75 and 51 per cent, inclusive; H, wheat, average of 11 tests, initial test less than 51 per cent.

however, the germination tests on different dates showed in general an improvement in vitality as the length of time after treatment increased, giving on the average the highest germination percentages on the last date, March 19 (curves C, D, G, and H). These relatively high percentages were sustained in the field germination tests, though all of the treated as well as all of the control seed, after having been kept dry, gave field germination tests uniformly lower than in the Seed Laboratory tests. This fact, as shown by the controls, was probably

due to field conditions. In some cases wheat which immediately after treatment, January 31, showed no germination, on March 19 showed 30 per cent and in the field 40 per cent. The results indicate that after the drying of the seeds after treatment a delay of one to two months not only does not injure but improves the germination where seeds have been severely treated. The detailed results of these tests are shown in Tables XIII and XIV, inclusive.

EFFECT OF JENSEN'S MODIFIED HOT-WATER TREATMENT ON THE YIELD OF GRAIN.

The percentages of germination in the foregoing tables indicate that from many of the treatments a decreased yield must result unless allowance is made in planting for injury to the seed. Those treatments selected as the best for barley (5-15-52) and wheat (5-10-54) cause little or no injury to germination. Swingle's method for wheat showed that successful treatment for loose smut of wheat was accompanied by a loss of as much as 25 per cent of the seed. Results of experiments to determine the effect of the treatments on yield are shown in Table XI. Plats of one-twentieth acre at St. Anthony Park, Minn., and of one-tenth acre at McPherson, Kans., were planted in each case. These plats were close together on a uniform soil, thus giving an accurate basis for comparison. In seeding no allowance was made for injury to seed germination. In general the stand on the treated plats appeared less uniform and slightly poorer than on the control plats. The yields were tested in a manner similar to that used for the testing of varieties at these stations.

In estimating the amounts of smut in fields which were too large to permit a count of all the heads or plants the following method, proposed by Mr. H. J. C. Umberger, has been found useful and accurate and has been adopted throughout. In this method a point is selected at random in one of the drill rows, and starting from this point in the row 100 heads are counted. A hand counting register is very useful in this work. Another starting point is then selected in a different row at some distance from the first and another 100 heads are counted. This is continued over the entire plat usually until the sum of a thousand heads is reached. The exact number of counts is determined by the size of the plat and the desire for accuracy. The greater the number of counts the more accurate is the result. In some cases only 600 heads were counted, in which case some of the plats were again checked up. At other times as many as 2,000 heads were counted in each plat. This method of estimating the prevalence of smut has some advantage over the hoop or square measure methods, especially in speed, and is even more accurate than these methods, by reason of the fact that the number of heads really expresses comparatively the number of plants, which is not always the case when other methods are followed.

TABLE XI.—*Results of experiments with Jensen's modified hot-water treatment on wheat and barley, showing the effect on yield of grain.*

ST. ANTHONY PARK, MINN., 1908.

Treatment.	Barley.			
	Minnesota No. 105.		Minnesota No. 195.	
	Smut.	Yield per acre.	Smut.	Yield per acre.
	Per cent.	Bushels.	Per cent.	Bushels.
Control.....	2	37	1.4	40.0
5-15-52*	Trace.	37	0	42.2
Ice 5-15-52.	0.1	33.9	.1	33.7
Wheat: Minnesota No. 188.				
Control.....	3.9	24.3	6+	22.3
5-10-54.....	† Trace.	** 20.6	Trace.	** 21.6
Ice 5-10-54.	4.2	20	.3	†† 20.3

McPHERSON, KANS., 1908.

Treatment.	Spring wheat: Kubanka No. 2094.		
	Smut.	Yield per acre.	Remarks.
	Per cent.	Bushels.	
Control.....	0.25	13.46	
8-15-54.....	0	11.63	Temperature varied from 53.5-54° C.; 54° C. most of time.
Ice 8-15-54.....	Trace.	12.42	Temperature varied from 53.5-54° C.; 54° C. most of time.
Barley: Caucasian No. 90.			
Control.....	1.25	35.83	
6-15-51.5.....	0	26.15	Temperature varied from 51°-51.5° C.; 51.5° C. most of time.
Ice 6-15-51.5.....	0	29.48	Temperature varied from 51°-51.5° C.; 51.5° C. most of time.

* For Minnesota No. 195, soaked 6 hours 20 minutes.

† Five heads found in whole plat.

** Temperature varied from 52.8° to 54° C.; 53.8° C. most of time.

†† Temperature varied from 54° to 53.2° C.; 53.4° C. most of time.

The uneven stand of the treated grain has already been noted. The cold-water soakings gave uniformly excellent results in the prevention of smut, leaving in no case more than a trace. This trace amounted to five heads or less in the whole plat, found by very careful search. In barley, Minnesota No. 195, not a smutted head was seen. The control in this case, however, had very little smut (1.4 per cent). The ice-water soakings were less successful, especially in wheat, where in one plat the treated grain had 4.2 per cent against

3.9 per cent in the control. These results confirm those shown in the previous table.

The yield at St. Anthony Park was slightly decreased by the treatment after cold-water soakings, while at McPherson it was quite seriously affected. In Minnesota barley it was practically equal to the control plat (exceeding it in Minnesota No. 195). In wheat there was a decrease in all cases, amounting to 15 per cent in one plat. Treatment after ice-water soakings invariably resulted in a loss in yield amounting in Minnesota No. 195 barley to 20 per cent. The ice-water treatments should, therefore, be discarded as undesirable in all respects.

Treatment after cold-water soakings, on the other hand, was successful in the prevention of smut, although a loss in yield was evident in most cases.

TEST OF THE JENSEN MODIFIED HOT-WATER TREATMENT ON A LARGE SCALE.

An attempt was made in 1907 and 1908 to test the Jensen hot-water treatment under the difficulties present at an experiment station where larger fields and more of them were planted than were found necessary in the previously described experiments. This work was conducted by Mr. H. J. C. Umberger, at McPherson, Kans., on the cooperative experiment station of the Office of Grain Investigations. There had been considerable smut at the station in 1906 in both wheat and barley, and an accurate estimate of the amount in most of the varieties in large plats was made in 1907. It was proposed to clean the entire place of smut in one year. All wheats and barleys on the station, with the exception of the hybrids, were treated in the fall of 1907. The hybrids, on account of a possible loss of seed, which could not be replaced, were left untreated.

The apparatus used in treatments was a 40-gallon galvanized-iron tub and a 2-burner gasoline stove. This and all other material necessary could easily be duplicated on an ordinary farm. The following treatments were employed: For wheat, 7-15-54, and for barley, 6-15-52. The conditions at the experiment station were, of course, even more difficult than on an ordinary farm, on account of the large number of varieties which it was necessary to handle. All treated seed was dried after treatment for at least a week previous to sowing.

The station farm comprised about 30 acres, fully one-half of which was in wheat and barley. There were 59 plats of wheat and barley of one-tenth and one-twentieth acre each, the majority being one-tenth-acre plats. An accurate smut record of 45 of the 59 plats was kept in 1907, while of the remaining 14 no record was taken, though probably smut was present. The smut varied from a trace on some plats to a maximum of 7.3 per cent on others, the average of the plats

being 2.1 per cent. All computations were made by Mr. Umberger according to the method previously described. In addition to the large plats, 550 varieties and selections, comprising about 2,000 rows, were individually treated. One man's time, nine hours a day for about two weeks, was consumed in this work. It was estimated that 40 lots of seed for as many one-tenth-acre plats were treated in five hours. This rate can be considerably increased with larger tubs and more heat and where only one or two varieties are handled, as under ordinary farm conditions.

The results of these treatments became evident in 1908. Not a head of smut could be found on the whole farm among the barley and common wheats (*Triticum vulgare*). A few varieties of durum wheats, however, had an occasional smutted head, constituting an exceedingly small fraction of 1 per cent. This probably indicates that durum wheats require a slightly more severe treatment than common wheats. The untreated hybrids, which, as previously stated, were the only untreated plants on the farm, contained 2 per cent of smut in 1908. This is the only check on the amount of smut at the station for the year. Conservatively estimated, it represents the percentage of smut eliminated by the treatment. The injury to germination caused by treatment was variable. It was not more than 25 per cent in any case where the seed was properly dried and kept dry, and probably on the average was less than 15 per cent under such conditions.

As shown by other experiments noted in this bulletin, the amount of time given to the drying of treated seed was undoubtedly unfavorable to germination. The seed might better have been planted immediately or allowed to rest for one to two months. It should also be pointed out that the injury to germination did not necessarily mean a commensurate decrease in yield. It seems probable that the yield was not affected to the extent shown by the decrease in germination, since the fewer plants had greater opportunities for stooling. This attempt to clean the farm of smut in one year was without question successful and demonstrated the possibility of using this method on a fairly large scale.

Mr. A. H. Leidigh, of Hutchinson, Kans., successfully used the modified hot-water treatment on his farm in 1907-8. In a letter to the Office of Grain Investigations, he says:

During vacation last fall I treated some Tennessee winter barley (from McPherson station) for loose smut as per specific directions from Mr. Umberger, of your office. This was for a farm field of barley; the work was done with ordinary farm equipment. I take pleasure in telling you that the modified hot-water treatment as used is a success. As the loose smut is increasing rapidly and is not to be controlled by ordinary methods, I consider our results of great importance.

ROGUING TREATMENT FOR THE PREVENTION OF LOOSE SMUTS OF WHEAT AND BARLEY.

Maddox^a found that by carefully picking out all smutted heads in small plats seed almost free of smut was obtained in two years. Experiments were undertaken in 1907 at St. Anthony Park to test this method and to determine its practical possibilities. The results are shown in Table XII.

TABLE XII.—*Results of experiments in the prevention of loose smuts of wheat and barley by roguing the smut, St. Anthony Park, Minn., 1907 and 1908.*

BARLEY.

Plat.	Variety.	1907.		1908.
		Treatment.	Smut.	Smut.
			<i>Per cent.</i>	<i>Per cent.</i>
C.....	Minnesota No. 105.....	Control; no treatment.....	* 1.69	2.0
A.....	do.....	Rogued.....	1.69	.2
B.....	do.....	Formalin; rogued.....	1.16	.5
E.....	Minnesota No. 142.....	Control; no treatment.....	* 4.62	2.0
D.....	do.....	Formalin; rogued.....	4.62	1.0

WHEAT.

F.....	Minnesota No. 188.....	Control.....	3 to 4	5.0
T.....	do.....	Formalin; rogued.....	.2	.5
S.....	do.....	do.....	4.0	.1

* Percentage from rogued plats.

Five plats (one-fortieth of an acre each) were laid off for the barley work. Three of these (A, B, and C) were sown to barley, Minnesota No. 105, and two (D and E) to Minnesota No. 142. Both barleys contained considerable smut in 1906. Plats C and E were control plats and were not treated. In plats B and D the seed before planting was immersed for two hours in a formalin solution (1 pound of formalin to 45 gallons of water) in order to test the efficiency of this treatment for both loose and covered smut. In these plats, as well as in plat A (which was not treated with formalin), all of the smut was picked every day. By frequent roguing it was hoped to get the smut heads before they had a chance to distribute their spores. The details of the pickings are shown graphically in figure 1, p. 16.

The five plats of barley were grown together in a row in order to test the roguing method under fairly adverse conditions. Roguing was very thoroughly carried out, and in the three plats pickings were made daily from July 2 to harvest (July 29). The time spent in roguing averaged approximately fifty hours per plat, an amount of

^a Maddox, F. Loc. cit.

time hardly allowable in farm practice. The test shows, however, the possibilities of the method even under the adverse conditions brought about by the close proximity of plats C and E to the rogued plats. In plats C and E the smut was allowed to be distributed in a natural manner and undoubtedly caused infection in adjacent plats. The nearest large barley fields were 600 feet to the west of these experimental plats. The percentage of smut in 1907 was 1.69 in Minnesota No. 105 and 4.62 in Minnesota No. 142 in the rogued plats (A and D). These were accepted for the controls, since the seed used in plats C and E was from the same bulk as the seed for A and D, respectively. In plat B (Minnesota No. 105) 1.16 per cent of smut was present. The seed obtained from these plats was planted in twentieth acres in 1908. The controls (C and E) were planted in the barley variety series, while the seed from the rogued plats A, B, and D was planted among the oat varieties remote from any barley fields. The smut in each plat was computed as previously described in connection with Table XI. The results show a decided decrease in smut in every rogued plat from that recorded for 1907. The decrease would undoubtedly have been greater if the rogued plats had been completely isolated the previous year (see Table XII, plat S). The results obtained indicate clearly that the smut can be greatly reduced by roguing the smutted heads as soon as they appear. It is almost certain, however, that this method would not prove practicable in farm practice on account of the time necessary to rogue even a small plat. It could be used only in connection with a seed-plat system.

Results similar to those obtained with barley were obtained with the loose smut of wheat. Minnesota No. 188, a bearded hard spring wheat, was used. Plats F and S were from the same bulk of seed. Plat T was from a different lot of seed, and no control was planted. T and S were one-tenth-acre plats both in 1907 and 1908, while control F was a large field at the station. Plat S was isolated among the barley varieties in 1907, while plat T was sown among the wheat varieties, with a plat of Minnesota No. 188 on one side and Preston wheat on the other. It was hoped that plat T would give a test of the roguing under unfavorable conditions, similar to the barley tests described above, but the amount of smut in 1907 was only 0.2 per cent as compared with 4 per cent in plat S and 3 to 4 per cent in the large fields. This small amount of smut makes the results in plat T of comparatively little value as a test for the roguing method. Plat S, however, shows conclusively the possibilities of the method when the rogued plat is isolated, since the decrease from 4 per cent in 1907 to 0.1 per cent in 1908 stands out in sharp contrast to the results in the large field controls, viz, 3 to 4 per cent in 1907 and 5 per cent in 1908.

The above experiments show that picking out the loose smut heads in both wheat and barley will decrease the amount of smut in the following crop. The best results are obtained by isolation of the plat (see Table XII, plat S), but a decrease is obtained even without isolation when the picking is carefully done. The roguing can be facilitated by pulling out the entire plant whenever a smut head appears. This will avoid the necessity of picking out several other smut heads later in the season. Planting the grain in rows 10 to 12 inches apart in order to allow walking between the rows also aids the roguing process.

The necessity for isolation is well shown in another series of experiments. From the treatment tests with Jensen's method made in 1907, Table VII, eight lots of seed of Minnesota barley No. 142 (1907 controls contained 6.9 per cent of smut), from which the smut had been entirely eradicated by the hot-water treatment, were selected. Since the treated grain had been sown in contiguous plats, the successfully treated rows during the season of 1907 were subject to inoculation by spores from the unsuccessfully treated and control plats which were usually less than a rod away. This seed from the smut-free rows when planted in 1908 gave in every case loose smut varying from 0.16 per cent to 2.4 per cent. The latter amount was equal to the untreated control of 1908, in Table XII, and shows an infection equal to that in nontreated seed. The same number of lots of wheat (Minnesota No. 188) was selected from successfully treated seed (Table IX) in 1907 under conditions similar to those described for barley. The results were in general the same. Although the seed came from rows with no smut in 1907, every lot contained smut varying from 0.1 per cent to 0.5 per cent in 1908. The increase in the smut was not as marked as in the barley, since the field control of the same wheat in 1908 had 5 per cent of smut, but in no case did the seed remain free from smut. Isolation is therefore very necessary to the maintenance of freedom from loose smut in both wheat and barley.

Just how far removed from a smutted field a plat must be in order to prevent infection entirely can not be definitely stated at this time, as no experiments have been performed to determine this point. Evidence presented in this bulletin indicates, however, that sufficient isolation of a seed plat can be obtained on an ordinary farm to avoid any considerable infection, and the maintenance of such a plat will soon reduce the smut on the farm to a mere trace and will ultimately eradicate it. Wind-borne spores travel long distances, but the possibilities of infection decrease very rapidly with the increase of the distance of the seed plat from the smutted fields. An intervening

grove or strip of wood between the seed plat and the smutted field is a very valuable protection.

In connection with the above-described treatments of barley for loose smut, tests made with the covered smut showed that the latter can be easily and completely destroyed by the hot-water treatments, such as 5-15-52, or by immersion in a solution of 1 pound of formalin to 45 gallons of water for two hours. Undoubtedly other treatments, such as are efficient for the bunt of wheat and the loose smut of oats, would also be useful against this smut. The roguing method carried on in connection with loose smut (see fig. 1 and Table XII) was fairly successful against covered smut in one case (Minnesota No. 105, Table XII, plat A). In another case (Minnesota No. 142, Table XII, plat C), where no covered smut appeared in the rogued plat in 1907, 1 per cent was present in 1908. The simplicity and efficiency of the formalin treatment make the practical consideration of the roguing method for the covered smut entirely unnecessary.

TABLE XIII.—*Effect on germination of drying the seed of barley after the application of Jensen's modified hot-water treatment, Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Date of treatment.	Germination tests of Seed Laboratory.					Germination in field, planted April 16.
		January 31.	February 6.	February 20.	March 5.	March 19.	
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Control.....		92.0	93.5	91.0	87.0	93.0	73.0
Ice 5-5-52.....	Jan. 29	93.0	95.5	92.0	91.5	92.0	78.0
Ice 5-10-52.....	do.	87.5	88.0	89.0	87.0	88.0	80.0
Ice 5-15-52.....	do.	85.5	92.0	89.5	89.0	92.5	82.5
Ice 5-5-54.....	do.	90.0	90.5	87.0	85.5	91.5	73.0
Ice 5-10-54.....	do.	85.5	83.5	72.0	80.0	87.0	70.0
Ice 5-15-54.....	do.	58.5	60.5	48.0	47.5	72.0	45.0
Ice 5-5-56.....	do.	70.0	77.5	70.5	62.5	80.0	65.0
Ice 5-10-56.....	do.	23.0	43.5	16.0	15.0	37.5	34.0
Ice 5-15-56.....	do.	5.5	7.0	3.0	2.5	20.0	17.0
Ice 5-5-58.....	do.	12.0		11.5		25.0	18.0
Ice 5-10-58.....	do.	1.5		5.0		3.5	2.0
Ice 5-15-58.....	do.	1.0		0		1.5	2.5
5-5-52.....	do.	95.5	96.5	95.5	95.0	95.5	87.0
5-10-52.....	do.	94.0	94.0	93.0	90.0	91.5	76.0
5-15-52.....	do.	92.0	94.0	94.0	92.0	93.5	77.0
5-5-54.....	do.	94.0	92.5	91.0	91.5	93.5	73.0
5-10-54.....	do.	80.5	79.5	79.5	81.0	85.0	63.0
5-15-54.....	do.	48.5	41.5	35.5	42.5	65.5	39.0
5-5-56.....	do.	11.5	37.0	21.5	17.0	46.5	33.0
Ice 13-5-52.....	Feb. 4	89.0		91.0	90.5	95.0	75.0
Ice 13-10-52.....	do.	89.5	77.0	79.0	86.0	88.0	77.0
Ice 13-15-52.....	do.	84.5	84.5	76.5	73.5	77.5	60.0
Ice 13-5-54.....	do.	87.0	93.0	85.0	81.0	89.5	76.0
Ice 13-10-54.....	do.	76.5	73.0	58.0	53.5	79.0	56.0
Ice 13-15-54.....	do.	51.5	37.0	29.5	37.5	58.0	38.0
Ice 13-5-56.....	do.	73.5	73.5	58.5	56.0	75.0	49.0
Ice 13-10-56.....	do.	22.0	24.0	10.5	12.0	31.5	20.0
Ice 13-15-56.....	do.	2.5	4.0	1.0	1.0	3.0	2.0
Ice 13-5-58.....	do.	4.5	0	5.0	0	6.5	5.0
13-5-52.....	do.	95.5		82.0		92.0	75.0
13-10-52.....	do.	92.5		70.5		88.5	60.0
13-15-52.....	do.	84.5	63.0	31.5		76.0	44.0
13-5-54.....	do.	89.5	89.0	75.5	74.0	86.0	68.0
13-10-54.....	do.	56.5	32.0	10.5	20.5	40.0	24.0
13-15-54.....	do.	4.5	9.0	2.5	3.5	13.5	3.0
13-5-56.....	do.	28.5	28.0	5.5	12.5	30.0	13.0

TABLE XIV.—*Effect on germination of drying the seed of wheat after the application of Jensen's modified hot-water treatment, Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Date of treatment.	Germination tests of Seed Laboratory.					Germination in field, planted April 16.
		January 31.	February 6.	February 20.	March 5.	March 19.	
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Control.....		92.5	94.0	94.0	95.0	92.5	68
Ice 5-5-51.5.....	Jan. 29	91.0	93.5	94.5	95.0	93.0	80
Ice 5-10-51.5.....	do.	90.5	91.0	91.0	95.0	92.0	82
Ice 5-15-51.5.....	do.	85.5	90.5	89.5	93.0	94.5	79
Ice 5-5-53.5.....	do.	87.5	89.5	92.0	94.5	91.0	83
Ice 5-10-53.5.....	do.	75.5	91.5	83.0	91.5	85.5	73
Ice 5-15-53.5.....	do.	53.5	76.0	70.0	79.0	80.5	71
Ice 5-5-55.5.....	do.	68.5	81.0	79.5	88.0	92.5	74
Ice 5-10-55.5.....	do.	39.5	72.5	56.5	78.5	71.5	70
Ice 5-15-55.5.....	do.	20.0	34.0	34.0	37.5	36.5	50
Ice 5-5-57.5.....	do.	8.5	50.0	46.0	52.5	61.0	50
Ice 5-10-57.5.....	do.	0	3.0	15.0	3.5	8.5	13
5-5-51.5.....	do.	93.5	94.5	94.5	94.5	94.5	81
5-10-51.5.....	do.	89.5	96.0	91.5	97.0	95.0	85
5-15-51.5.....	do.	91.0	94.0	91.5	95.5	95.0	79
5-5-53.5.....	do.	87.0	92.0	92.5	92.5	93.0	82
5-10-53.5.....	do.	67.0	85.0	90.5	92.0	92.5	75
5-15-53.5.....	do.	21.5	62.0	62.5	67.0	80.0	66
5-5-55.5.....	do.	21.5	73.0	62.0	72.5	81.5	66
5-10-55.5.....	do.	0	12.5	9.5	12.5	30.0	40
Ice 13-5-51.5.....	Feb. 4	89.5	93.0	90.0	92.0	91.0	81
Ice 13-10-51.5.....	do.	87.5	89.0	92.5	90.0	96.5	80
Ice 13-15-51.5.....	do.	93.0	95.5	82.5	94.5	87.5	78
Ice 13-5-53.5.....	do.	89.5	91.5	91.5	90.5	89.0	80
Ice 13-10-53.5.....	do.	85.5	80.0	83.5	67.0	82.5	74
Ice 13-15-53.5.....	do.	81.5	76.0	65.5	82.5	77.5	66
Ice 13-5-56.....	do.	67.5	52.0	41.0	52.5	73.5	51
Ice 13-10-56.....	do.	21.5	12.0	6.5	4.5	15.0	32
Ice 13-15-56.....	do.	4.0	.5	0	1.5	1.0	7
13-5-51.5.....	do.	93.5	93.0	95.0	93.5	92.5	82
13-10-51.5.....	do.	93.0	86.5	89.5	94.5	89.5	79
13-15-51.5.....	do.	88.0	88.5	91.0	92.0	88.5	74
13-5-53.5.....	do.	90.5	88.0	90.0	91.5	89.5	69
13-10-53.5.....	do.	90.0	-----	76.0	-----	80.5	58
13-15-53.5.....	do.	74.5	58.5	47.5	60.0	72.0	49
13-5-56.....	do.	18.0	2.0	0	14.0	65.0	22

RECOMMENDATIONS.

According to the experiments previously described, two methods gave a decrease of smut. The first of these, the roguing method, although it decreases the smut does not eliminate all of it, and is, moreover, impracticable in handling large fields or even in small fields, on account of the work which it involves. It is useful, however, in nursery plats where hybrid plants and small quantities of pedigreed seed are being raised and where injurious treatments would mean a loss of seed that could not be replaced. An attempt to use it in combination with a seed-plat method would require several years at least to eliminate all of the smut. It can not, therefore, be recommended as a treatment for general practice in preventing loose smut.

The second method is Jensen's modified hot-water treatment. This has been entirely successful. It can not at present be recommended for the treatment of seed for large areas, however, but in combination with a seed-plat system it is entirely practicable and its use can be

urged for general farm practice.^a Its application requires care and intelligence, and it can best be used with small lots of seed. In general, the method to be recommended is the following: The keeping of a seed plat the seed for which has been cleaned of smut by the application of Jensen's modified hot-water treatment and the use of the grain from this plat for seed the succeeding year, when no further treatment is necessary. If the farm is very large it may require several years to get the smut entirely eliminated from the whole farm. This recommendation involves two processes, which will now be described.

SELECTION OF THE SEED PLAT.

A good, clean, well-cultivated piece of land should be selected and set aside for the raising of seed for the succeeding year. For this plat seed should first be carefully cleaned and selected by the best fanning and sifting processes. This seed should then be treated as directed later. The plat ought to be large enough to provide at least twice as much grain as will be necessary for farm seed the following year, in order to allow for loss in cleaning and selecting. This seed plat must not be placed next to fields of smutted crops of the same cereals. The plat ought also to be located so that the prevailing winds at flowering time will not carry spores to the seed plat from a neighboring field of the same grain. The isolation of this plat from smutted crops of the same cereal is absolutely necessary, not only from crops on the owner's farm but from neighboring farms as well. A strip of wood, a cornfield, a large meadow, or a barley or oat field intervening between the wheat seed plat and fields of smutted wheat will be useful, and similarly a field of corn, oats, or wheat or a large meadow or strip of wood between the barley seed plat and the smutted field will be a valuable protection. This point can not be too strongly emphasized and the cooperation of neighbors may be necessary to carry it into effect.

TREATMENT OF THE SEED FOR THE SEED PLAT.

After seed for the plat has been properly cleaned it must be treated by the Jensen method to eliminate the smut. This can be done according to the following directions: The clean seed should be soaked for from five to seven hours in water at ordinary room temperature, 17 to 22° C. (63 to 72° F.). It should be placed in small,

^a It may be possible to construct machines to make a general farm practice of treatment of large lots of seed possible, but none such is at present on the market.

loose sacks or wire baskets containing not more than one-half peck each and drained for a short time. It is of the greatest importance that the seed be treated in small lots in order that all of the grain may be quickly and uniformly brought to the desired temperature. Two tubs or vats of water should be provided. In one tub (No. 2) the exact temperature required should be maintained. The other tub (No. 1) is used for bringing the grain to the temperature of the treatment, so as not to lower the temperature in tub No. 2. Galvanized-iron tubs of 20 to 40 gallons capacity and kerosene or gasoline double-burner stoves are sufficient for treatment. The drained sacks or baskets of seed should be plunged into tub No. 1 for a minute, then transferred to tub No. 2, and kept agitated while immersed at temperatures and for the periods specified below, the temperatures mentioned being maintained as nearly as possible:

For barley, 15 minutes at 52° C. (125.6° F.).

For wheat, 10 minutes at 54° C. (129.2° F.).

In treating barley, if the temperature should rise above 52° C. (125.6° F.) the time of immersion must be reduced to ten minutes at 53° C. (127.4° F.) or five minutes at 54° C. (129.2° F.). Above 54° C. (129.2° F.) there is no safe margin. If the temperature falls slightly below 52° C. (125.6° F.) the time of treatment should be increased in proportion. A temperature lower than 51° C. (123.8° F.) will not be effective. In treating wheat, if the temperature should rise above 54° C. (129.2° F.) or fall below 52° C. (125.6° F.), the time for immersion must be diminished or increased accordingly. Under no circumstances should a temperature of more than 55° C. (131° F.) be allowed. Temperatures below 51° C. (123.8° F.) are ineffective.^a

Seed treated as indicated may be planted as soon as it is sufficiently dry to run freely through the drills. Allowance must then be made for the swollen seed and also for injury in treatment. The increase due to swollen seed can be estimated by measuring seed before and after treatment. The seed may be treated several months before seeding time and then dried quickly and carefully. In many cases the grain germinates as well or better when rested after treatment than if sown immediately. The seed may be dried by spreading it out in thin layers not over 2 inches in depth on a clean granary floor or on canvas and shoveling or raking it from time to time. It must not be allowed to sprout. Care must be taken to prevent the freezing of the grain when it is moist, as this will impair germination.

^a Two men working together can easily treat one bushel of grain an hour, or enough seed in one day to sow a seed plat from 6 to 10 acres in size.

A good thermometer should be used for all treatments.* The use of an instrument which is not accurate will result in injury to the germinating power of the grain on the one hand or in failure to prevent the smut on the other.

Several weeks before sowing, the seed should be tested for germination. This can be done by placing several small lots of grain of 100 seeds each between damp blotters and keeping them at a living-room temperature for several days. The percentage of sprouted kernels will show the power of germination. If this is low, a corresponding increase in the rate of seeding is necessary.

The seed plat should be maintained from year to year, at least as long as any smut is present on the farm. Seed obtained from the treated seed plat does not have to be treated the following year. All fields that are free from smut must be kept separated, as previously stated, from smutted fields of the same grain. Cooperation with neighbors may be necessary to bring this about.

SUMMARY.

The loose smuts of wheat and barley demand treatment in many sections of the United States on account of their wide distribution, evident increase, and possible virulence, and on account of the difficulty of preventing them.

The loose smuts of wheat, barley, and wild barley are distinct species and are not interchangeable as to their host plants.

The loose smuts of wheat and barley infect the plant in the flowering stage and enter the embryo inside of the ovary before the latter ripens into the seed. An infected seed develops a smutted plant the following year.

Varietal differences in susceptibility to these smuts have been observed in both wheat and barley, but no immunity of marked practical value has been discovered. There apparently is no constant relationship between susceptibility and earliness of ripening.

* Thermometers may be submitted to the Bureau of Standards, Washington, D. C., for test. A charge of about 50 cents will be made for testing at the two points necessary. They should be graduated in single or half degrees—centigrade—directly upon the stem or upon a scale contained within the stem, and should preferably read from 0° to 100°. The bulbs, at least, should be made of a suitable glass, such as Jena "Normal" thermometer glass or Corning Medium thermometer glass, in order that the readings may not change with time, and the general construction of the thermometer should be good. However, thermometers with the Bureau of Standard's certificates can be purchased directly from manufacturers or large dealers, and this is generally a much more convenient way to secure them, because it avoids the risk and expense of shipping them to and from Washington.

Artificial inoculations of flowers with loose smut from the time when the stamens are still green to the time when the ovary is one-third its mature size are usually successful. The optimum period for artificial inoculation is at the time when the flower is in full bloom or when the ovary is just commencing to develop after fertilization.

The time of maximum smut in a field of wheat or barley corresponds exactly with the full flowering period of the crop.

The partial smutting of plants and of heads is common; this is possibly associated with the time of inoculation or with weather conditions. Sound grains on partially smutted heads are not infected by the mycelium growing inside the plants on which the seeds are formed.

The time of planting of spring wheats and barleys had no effect on the loose smuts at St. Anthony Park, Minn. In winter barleys at Amarillo, Tex., however, very late planting resulted in almost no smut, while planting at the ordinary time or earlier in the season resulted in a large amount of smut. The absence of smut on the late plantings is probably due to a difference in optimum temperature for the internal smut and the seed germinations.

The effects of Jensen's method on the germination of wheat and barley for different periods of previous soaking and for different temperatures and time limits are shown in Tables V and VI. In general the germination is injured, though variously, according to the severity of the treatments.

The effects of Jensen's method on the loose smut of wheat and barley for different periods of previous soaking, different temperatures, and times of treatment are shown in Tables VII and VIII. The best treatments are the following: For barley, a soaking in cold water for five hours, followed by a soaking in hot water for fifteen minutes at a temperature of 52° C.; for wheat, a soaking in cold water for five hours, followed by a soaking in hot water for ten minutes at a temperature of 54° C. These treatments if carefully carried out entirely prevent the smut and produce only slight injury to the germination of the seed.

Thorough drying of the seed after the application of Jensen's modified hot-water treatment is not injurious to the germination. When seed is injured by the treatment, the germination improves after several weeks of drying, and continues to improve for at least two months. (See Tables VIII, XIII, and XIV, and fig. 2.)

Soaking the seed in ice water previous to the hot-water treatment is not as efficient against smut as soaking in cold water at ordinary temperatures.

The application of Jensen's modified hot-water treatment will result in a decrease in yield, unless an allowance for slightly injured germination is made in sowing. With the best treatments the decrease is very small.

Picking out the loose smut of wheat and barley decreases smut even without isolation of the plat; the decrease is more marked, however, when the plat is isolated. The roguing method is nevertheless impracticable in farm practice on account of the time required and because it does not completely clean out the smut. It is useful, however, in breeding plats.

The treatment of wheat and barley seed with formalin has no effect on the loose smut. The use of formalin will, however, completely prevent covered smut of barley and bunt of wheat.

All smuts of wheat and barley, including bunt and loose smut of wheat and covered and loose smut of barley, were practically eliminated from a 30-acre experimental farm in one year by the use of Jensen's modified hot-water treatment. This method can therefore be used on a fairly large scale where accuracy and care are employed.

The following method for farm practice is recommended: Grow seed in a small isolated seed plat, using clean, heavy seed of the best quality and of pure stock. Treat this seed carefully by Jensen's modified hot-water method as recommended in this bulletin and sow the seed according to germination tests. Plant the seed from the seed plat the following year for the general farm crop. Maintain the seed plat every year.

PLATES.

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DESCRIPTION OF PLATES.

[The photographs for all plates were made by Mr. H. D. Ayer, Minnesota Agricultural Experiment Station, St. Anthony Park, Minn.]

PLATE I. Heads of wheat and barley, showing the common smuts. *a*, Bunt or stinking smut of wheat (Fife); head to the right with glumes removed to show smutted kernels (smut balls) in place; two whole and two broken smut balls shown below. *b*, A sound head of wheat (Minnesota No. 188), with sound grains shown below. *c*, Loose smut of wheat (Minnesota No. 188); to the right a head from which all of the spores have been blown, leaving the bare stalk. *d*, Two heads of covered smut of barley (Minnesota No. 105). *e*, A sound head of barley. *f*, Loose smut of barley; to the right a head from which the spores have been blown.

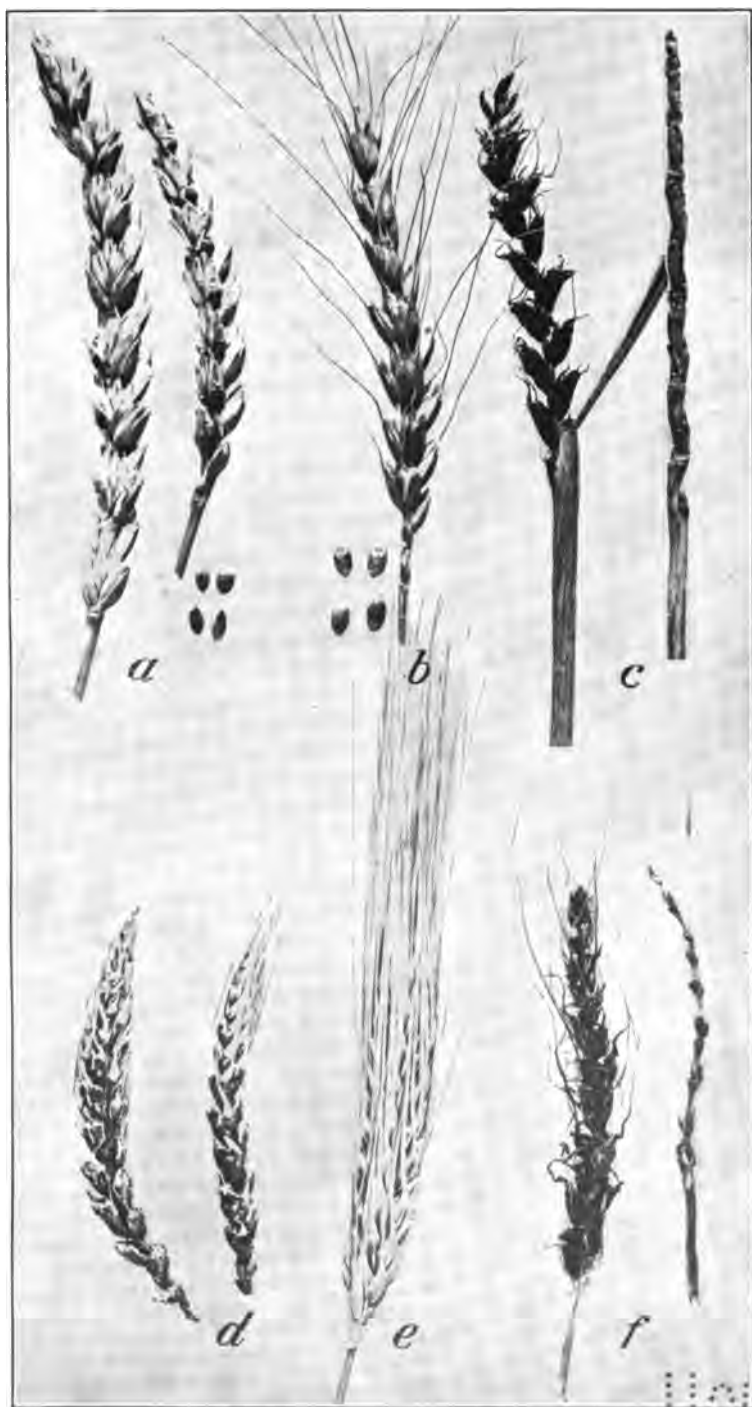
PLATE II. Loose smut of barley (Minnesota No. 105), showing the various stages in the development of a smutted head. *a*, Head just appearing in the boot (sheath); *b*, half out of the boot; *c*, mature in size, but not yet distributing spores; *d*, smut mass broken and distributing spores; *e*, all of the spores blown off and the bare stalk of the head left.

PLATE III. Loose smut of barley (Minnesota No. 105), showing various manifestations of smut. *a*, Sound head; *b*, partially smutted head, upper spikelets sound; *c*, completely smutted and mature head, showing powdery mass of smut; *d*, smut head formed late in the season and never developing a powdery mass of spores; *e*, a badly smutted head, showing a smutted bract at the base of head.

PLATE IV. Loose smut of wheat, showing the various stages in the development of a smutted head as described for barley in Plate II. The smut is broken into powdery masses as soon as the head emerges from the boot. (Compare with Plate II.)

PLATE V. Loose smut of wheat (Minnesota No. 188). *a*, All of the heads of one sound plant—all sound; *b*, all of the heads of one smutted plant—all smutted; *c*, a partially smutted head of wheat—upper spikelets sound.

PLATE VI. Loose smut of barley (Minnesota No. 105). Upper row—all of the heads of one sound plant—all sound; lower row to the left—all of the heads of one smutted plant—all smutted; lower row to the right—all of the heads of a partially smutted plant—six smutted and one sound.



HEADS OF WHEAT AND BARLEY, SHOWING THE COMMON SMUTS.

1111



LOOSE SMUT OF BARLEY, SHOWING THE VARIOUS STAGES IN THE DEVELOPMENT OF A SMUTTED HEAD.



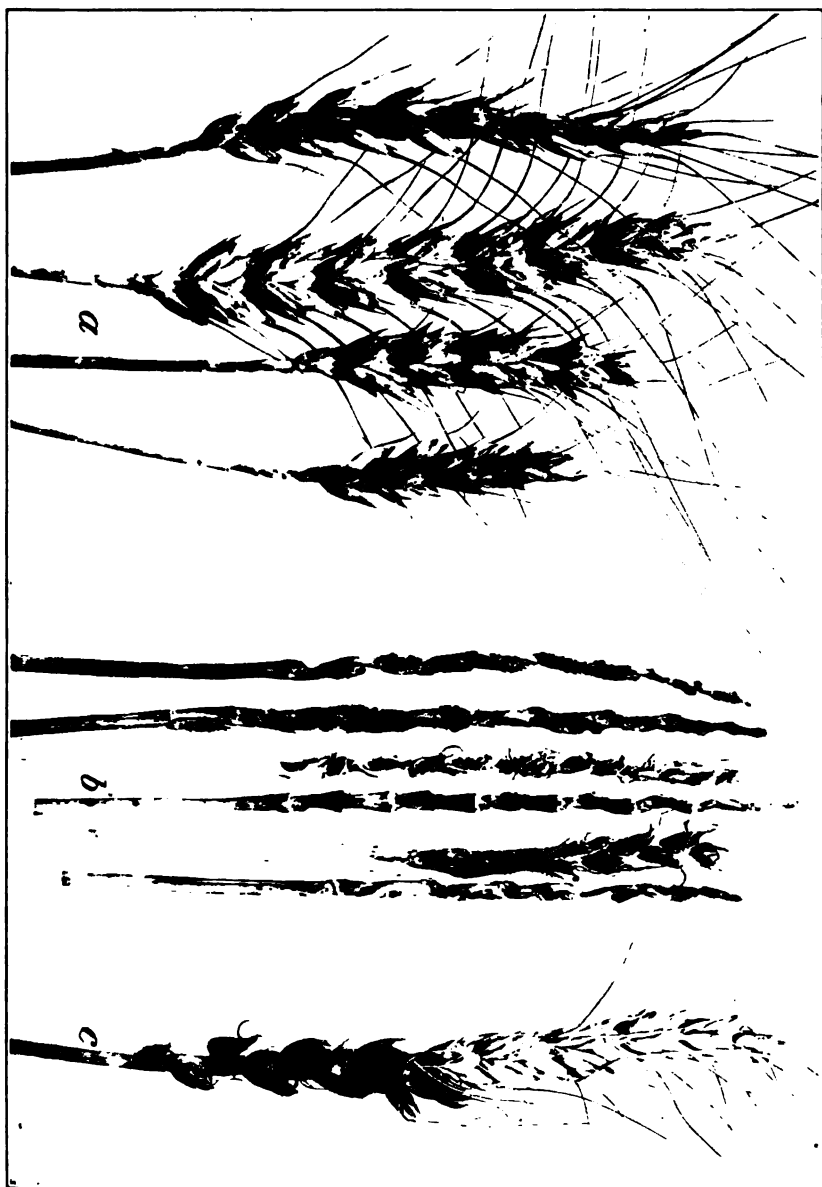
LOOSE SMUT OF BARLEY, SHOWING VARIOUS MANIFESTATIONS OF SMUT.

1701



LOOSE SMUT OF WHEAT, SHOWING THE VARIOUS STAGES IN THE DEVELOPMENT OF A SMUTTED HEAD.

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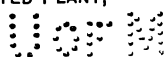


LOOSE SMUT OF WHEAT, SHOWING HEADS FROM A SOUND PLANT AND FROM A SMUTTED PLANT AND A PARTIALLY SMUTTED HEAD.

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LOOSE SMUT OF BARLEY, SHOWING HEADS FROM A SOUND PLANT, A SMUTTED PLANT,
AND A PARTIALLY SMUTTED PLANT.



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150. Wild Alfalfas and Clovers of Siberia. 1909. Price, 10 cents.
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 153.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM OCTOBER 1
TO DECEMBER 31, 1908:

INVENTORY No. 17; Nos. 23745 to 24429.

ISSUED JUNE 30, 1909.



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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.

Assistant Chief of Bureau, ALBERT F. WOODS.

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FOREIGN SEED AND PLANT INTRODUCTION.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 14, 1909.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 153 of the series of this Bureau, the accompanying manuscript, entitled "Seeds and Plants Imported During the Period from October 1 to December 31, 1908: Inventory No. 17; Nos. 23745 to 24429."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1908: INVENTORY NO. 17; NOS. 23745 TO 24429.

INTRODUCTORY STATEMENT.

It has been the custom for some time to mention in the introductory statement a few of the new arrivals which seem to be worthy the particular attention of the interested plant breeders and experimenters throughout the country. This does not mean that they will in the end prove the most valuable, for often the promising introductions are "dead failures," while those which come in like poor emigrants with scarcely a letter of introduction frequently crop up later somewhere in the country as new and valuable cultivated plants.

Those who are interested in the remarkable Chinese vegetables, whose possibilities have not at all been tested as they should be in this country, will find Mr. Meyer's collection, which he brought back personally from Peking, a most interesting one (No. 23932 and following). There can be little doubt that the Chinese restaurants which are scattered all over the country are creating a taste among Americans for these new vegetables, and the next step in their introduction will be their culture on a small scale to supply the growing demand of these restaurants.

Mr. W. T. Swingle has called attention to the possibilities of the Indian bael fruit (No. 23745), both as a possible new fruit which is prized in India and as a dry-land stock for the orange, and living plants of it have been secured.

Through Mr. Pink, a plant breeder of Queensland, a new raspberry has been secured which he claims has already become a favorite in Australia (No. 23478).

The Florida and California growers of the fruiting hedge plant *Carissa* will be interested in the newly secured species from Calcutta (No. 23750).

A new green-manure legume from Sao Paulo, Brazil, is highly recommended by Professor Hart (No. 23751).

A large collection of beans, cowpeas, squashes, field peas, and garbanzos and some remarkable hard-stemmed bamboos, which are quite different from the ordinary oriental bamboos, have been sent by Mr. Husbans (No. 23755 and following; No. 24211 and following; No. 24358 and following).

A number of additions to the strains or varieties of alfalfa have been made from Peru, Australia, Spain, and Chile. These are eagerly tried by the experts of the Department, who recognize the great possibilities which lie in any strain of this important plant which may fit into one of the many special conditions in the country.

A collection of seed from grasses representing the best grazing species on the veldt of Rhodesia (No. 23920 and following) will be tested by the agrostologist of the Department.

Mr. Meyer's collection of Chinese hollyhocks, prince's-feathers, morning-glories, four-o'clocks, balsams, Chinese pinks, marigolds, garden asters, etc., may have something of decided interest in it for American florists (No. 23995 and following).

A number of Syrian pomegranates from Sidon have come in for the experiments of the specialist of the Department, who is showing the possibilities of this fruit in America, which has so far been neglected by Americans.

A wild gooseberry from an altitude of 10,000 feet, which is used as a hedge plant in the Szechuan Province of central China, and a wild strawberry of good flavor from the same locality have been secured by Mr. Wilson, of the Arnold Arboretum (Nos. 24156 and 24165).

Two wild and possibly valuable dahlias from Mexico were sent in by Doctor Rose for the dahlia breeders (Nos. 24168 and 24169).

The Bahia Navel orange has been reimported by Consul Demers direct from Bahia, scions being taken from trees that were grafted on the "Laranja da terra" which are said to yield better fruits than those grafted on the "Laranja tanga," two different stocks in use there.

A distinct variety of the Para grass which has been so valuable in Texas has been secured from southern Brazil for trial in comparison with that already introduced (No. 24402).

A collection of Stizolobium, or velvet beans, has been sent on request by Director Treub, of the Royal Botanic Gardens of Java, for the purpose of comparison with the recently introduced species from the Philippines which has proved so unusually promising.

The inventory covers a period of three months, from October 1 to December 31, and includes 685 separate introductions. The preparation of the manuscript has been in the hands of Miss Mary A. Austin, and the determinations of the material have been made by Messrs. W. F. Wight and H. C. Skeels, of the Office of Taxonomic and Range Investigations.

DAVID FAIRCHILD,

Agricultural Explorer in Charge.

OFFICE OF FOREIGN SEED AND PLANT INTRODUCTION,

Washington, D. C., April 3, 1909.

INVENTORY.

23745. BELOU MARMELOS (L.) W. F. Wight. Bael tree.

From Savannah, Ga. Presented by Rev. Henry W. Hale. Received October 6, 1908.

See No. 22957 for description.

23746. BAMBOÛ SENANENSIS Franch. et Sav. Bamboo.

From Japan. Presented by the Yokohama Nursery Company, Yokohama, Japan. Received October 2, 1908.

"*Misuzudake*. This is a dwarf variety of bamboo growing wild at high altitude in the province of Shinshiu." (*Yokohama Nursery Company*.)

23747. MANGIFERA INDICA L. Mango.

From Amritsar, Punjab, India. Procured from Mr. Theo. C. Maller. Received October 8, 1908.

Maller.

23748. RUBUS ROSAEFOLIUS ♀ × ELLIPTICUS ♂. Raspberry.

From Wellington Point, Brisbane, Queensland, Australia. Presented by Mr. James Pink. Received October 3, 1908.

"*Federal*. This is a cross between a variety received from Japan under the name of *Rubus flava* (= *R. ellipticus* Sm.), a strange growing plant, but useless commercially; this was the male parent, the mother parent being our native *Rubus rosae-folius* Sm. I crossed the plants in 1901. I did not think much of the product till the present season, when the variety has improved much by cultivation and has become a great favorite in the markets; in fact, it is the only *Rubus* grown for commercial purposes in Queensland. The fruit is larger than the English raspberry and of a bright crimson color." (*Pink*.)

23749. MEDICAGO SATIVA L. Alfalfa.

From Lima, Peru. Presented by Señor Ignacio La Puente, through Mr. Charles J. Brand. Received July 10, 1908.

"Señor La Puente states that this seed is from the latest crop, that it emanates from the Department of Supe, and that the variety is one greatly prized in the coast country of Peru. Kaerger in his paper 'Die Landwirthschaft in Peru' states that in the coastal region of Peru, alfalfa, strange to say, will not grow in the height of summer (January and February), even though it be given ample irrigation. The esteem in which this variety is held may bear some relation to this fact." (*Brand*.)

23750. CARISSA CARANDAS L.

From Sibpur, Calcutta, India. Presented by Mr. W. W. Smith, acting superintendent, Royal Botanic Garden. Received October 1, 1908.

23750—Continued.

"A dense, spiny shrub or sometimes a small tree, flowering from February to April (in India) and bearing a small fruit which is grape-green when young, changing to white and pink as it approaches maturity, and black when fully ripe. The fruit ripens from July to August.

"In India the fruit is made into pickle just before it is ripe, and is also employed in tarts and puddings. For these purposes it is said to be superior to any other Indian fruit. When ripe it makes a very good jelly equal to the red currant, for which purpose it is cultivated in the gardens owned by Europeans. The shrubs are also grown for hedges." (*Watt, Dictionary of Economic Products of India*, 2: 165. 1889.)

"This ought to be of value in southern California where the red currant does not thrive." (*W. F. Wight*.)

23751. STIZOLOBIUM sp.

From Piracicaba, Sao Paulo, Brazil. Presented by Prof. J. William Hart, director, Agricultural College. Received September 14, 1908.

"I think this will prove one of our best legumes for green manuring." (*Hart*.) Grown from No. 21094. See this number for description.

23752 and 23753. MEDICAGO SATIVA L.**Alfalfa.**

From Australia. Presented by Mr. Elwood Mead, The State River and Water Supply Commission, Treasury Gardens, Melbourne, Australia, who procured the seed from F. H. Brunning, Pty. Ltd., Melbourne, Australia, at the request of Mr. Charles J. Brand. Received August, 1908.

Seed of each of the following:

23752. *Hunter River or Tamworth.* "This comes from the chief alfalfa-growing district in Australia." (*Mead*.)

23753. *Queensland.* "This alfalfa was grown at Clifton on the Downs by a man who is well up in the saving of a good strain of broadleaf alfalfa." (*Brunning*.)

23754. EDGEWORTHIA GARDNERI (Wall.) Meism.**Mitsumata.**

From Yokohama, Japan. Procured from the Yokohama Nursery Company. Received October 12, 1908.

See No. 9162 for description.

23755 to 23869.

From Chile. Received from Mr. José D. Husbands, Limávida, Chile, October 7, 1908.

The following seeds and plants, descriptive notes by Mr. Husbands; native names quoted:

23755 to 23759. PHASEOLUS VULGARIS L.**Bean.**

23755. Extra fine. Grown dry in sandy soil, coast.

23756. "Amidon" (starch). Extra good.

23757. "Coscorones Baya Pintado." Extra good class for any use. Good land.

23758. "Bayas Chico" (small bay).

23759. "Mendez." Grown in black clay, irrigated.

23760. VIGNA UNGUICULATA (L.) Walp.**Cowpea.**

"Corregüela." Very good and extra prolific at the tops or points.

24755 to 23869—Continued.**23761 to 23834. PHASEOLUS VULGARIS L.****Bean.**

23761. Name unknown. Extra fine class.
 23762. "*Coscorones Baya*." Extra fine class. Prolific.
 23763. "*Entremetido Chico*" (small meddler). A commercial bean largely sown but not of the best quality. Stands droughts and grows in any soil.
 23764. "*Blanco*." Extra good for any purpose.
 23765. "*Barroso*" (muddy). Extra good class.
 23767. Extra early.
 23768. "*Aparcido*" (found). White pods.

The above (S. P. I. Nos. 23755 to 23768) grown by irrigation.

23769 to 23786. Grown dry about 10 miles from the sea.

23769. "*Rosilos de Reigo*." Largely sown.
 23770. "*Rosilos de Rulo*." Largely sown.
 23771. "*Porotos Lacre*" (red beans). Grown dry in poor sandy soil.
 23772. Grown in poor light soils.
 23773. White. Extra fine class; grown in poor soil.
 23774. Yellow. Grown dry on coast.
 23775. Extra good class; grown in poor soil.
 23776. Extra fine; grown in sandy soil.
 23777. "*Bayas Chico*" (small bay). Grown in poor soil. Seed mixed.
 23778. "*Mantequilla*" (butter). Extra superfine class.
 23779. Yellow and red. Grown in poor sandy soil.
 23780. "*Burro Claro*" (light-colored donkey). Extra good class; grown in poor soil.
 23781. Light yellow, medium size. Grown in poor soil.
 23782. Cream and black. Medium quality; grown in bad soil.
 23783. "*Burro Oscuro*" (dark donkey). Extra good class; grown in poor soil.
 23784. Light yellow. Grown dry on the coast.
 23785. Small, white, good; grown in bad soil.
 23786. "*Amarillos Chico*" (small yellow). Grown in poor soil.
23787 to 23828. Stringless or garden beans grown by irrigation.
 23787. Mixed, grown in clay soil.
 23788. Round, yellow.
 23789 and 23790. (No description.)
 23791. Very good and productive.
 23792 to 23795. (No description.)
 23796. Brown.
 23797. Good class.
 23798 and 23799. (No description.)
 23800. "*Palo*" (stick).

23755 to 23869—Continued.**23761 to 23834—Continued.****23787 to 23828—Continued.**

- 23801.** Good sort.
- 23802.** "*Siete Semanas*" (seven weeks). Good.
- 23803.** (No description.)
- 23804.** "*Overos*." Good.
- 23805.** Early and very prolific.
- 23806.** Extra early and prolific.
- 23807.** Can be grown dry in loose, sandy soil.
- 23808.** Can be grown dry in loose, sandy soil.
- 23809 to 23811.** (No description.)
- 23812.** A good class.
- 23813 to 23815.** (No description.)
- 23816.** Geese beans.
- 23817 to 23819.** (No description.)
- 23820.** Green color. Rare.
- 23821 to 23827.** (No description.)
- 23828.** An extra early bean; grows two crops per year when irrigated.

23829 to 23834. Stringless or garden beans from the coast; grown dry.

- 23829.** "*Trigo*" (wheat). Extra superfine quality. Prolific.
- 23830.** Extra prolific.
- 23831.** "*China Lejos Grande*." Grown dry in any soil.
- 23832.** All sorts. Grown dry in any soil.
- 23833.** Grown in poor, sandy soil.
- 23834.** No name.

23835 and 23836. PHASEOLUS COCCINEUS L. **Scarlet runner bean.****23835.** Pink.**23836.** "*Parjares*." Said to be different from other white classes. Grown by marine dews only.

These beans grow in any soil without losing their size or merit. The difference between suitable good and bad land sowing is chiefly in the greater or lesser yield.

23837 to 23840. CUCURBITA sp. **Squash.****23837.** Extra good class.**23838.** Extra good; sweet, fiberless, prolific, meat solid; small cavity for seeds.**23839.** A very good class.**23840.** Pinkish color, large, thick flesh, sweet, mealy, prolific, good.**23841.** CUCURBITA MAXIMA Duch. **Squash.**

Extra good class.

23842 to 23844. CUCURBITA sp. **Squash.****23842.** Black skinned; thick, sweet, fiberless flesh; extra good.

23755 to 23869—Continued.**23842 to 23844—Continued.****23843.** Extra good class.

The above (S. P. I. Nos. 23837 to 23843) grown by irrigation.

23844. Not as good as watered sorts.**23845.** *CUCURBITA MAXIMA* Duch.**Squash.**

Good class; sweet, thick, fiberless meat.

The above (S. P. I. Nos. 23844 and 23845) grown dry near the coast. The squashes grown dry are of little merit when compared with the irrigated sorts.

NOTE.—“These squashes listed as *Cucurbita* sp. are probably *Cucurbita maxima* Duch., but not determinable until grown. These seeds are very different from any squash seeds found heretofore.”—(W. F. Wight.)

23846 to 23851. *PISUM ARVENSE* L.**Field pea.**

The following are common field peas grown dry in poor, sandy soil:

23846. A large, extra sweet field pea; fall sown.**23847.** The most ordinary sort.**23848.** The most ordinary sort; seed mixed.**23849.** Ordinary white peas; grown in poor soil.**23850.** Common peas; grown in poor soil.**23851.** Grown in bad soil.**23852 to 23855.** *CICER ARIETINUM* L.**Chick-pea.****23852.** “*Garbanzos Chico*” (small). Grown dry in red clay.**23853.** “*Garbanzos Grande*” (large). Grown dry in loose soil near coast.**23854.** “*Garbanzos Negro*” (black). Grown dry in red clay.**23855.** “*Garbanzos Grande*” (large). Grown dry in clay soil.

These peas (S. P. I. Nos. 23846 to 23855) are not samples of the many best classes that can be had elsewhere in Chile, but are samples of the common hardy sorts that grow dry on hills whose soil is so poor that no vegetation of any kind exists except a few stunted red oaks. These are sown broadcast upon the ground and plowed in.

23856 and 23857. *LATHYRUS SATIVUS* L.**Grass-pea.****23856.** “*Chicharos Grande*” (large). Grow dry in any soil. Grow larger or smaller according to the quality of the soil.**23857.** “*Chicharos Chico*” (small). Grow dry in any soil. Always small no matter what class of soil.**23858 and 23859.** *LENS ESCULENTA* Moench.**Lentil.****23858.** “*Lentejas Rosillos*” (gray lentil). Grown dry in bad soil.**23859.** Common lentils. Grown dry in bad soil.**23860.** *PISUM SATIVUM* L.**Pea.**

“*Arvejones*.” A class of stringless peas. Both peas and pods are eaten.

23861. *HORDEUM VULGARE* L.**Barley.**

“*Poda*.” Grain head has 8 rows. This is mixed with other classes having 2, 4, and 6 rows of grain, respectively. The 4-rowed is called “*Caballuna*.”

23862. *HORDEUM* sp.**Barley.**

Common class grown in damp land; is discolored by the moisture of heavy dews.

23755 to 23869—Continued.**23863. JUGLANS NIGRA L.****Black walnut.**

Black walnuts long grown dry in Chile, but are not native of the country.

23864. CHUSQUEA VALDIVIENSIS E. Desv.**Bamboo.**

Colihue or bamboo. Solid stem, grows about 20 to 25 feet high, slightly drooping, small scant foliage, short joints, very tough, grows dry on any poor soil, extra hardy.

23865. CHUSQUEA VALDIVIENSIS E. Desv.**Bamboo.**

Colihue or bamboo. Solid stem, grows straight from 25 to 30 feet high, abundance of small, long-leaved foliage, a good industrial class, grows dry on any arid soil, extra hardy.

23866. ARUNDO DONAX L.**Giant reed.**

Colihue or bamboo. Hollow stem, grows erect, about 25 to 30 feet high; roots extend on top of the ground. From top to bottom has a rank leaf growth, like corn leaves, extending from two opposite sides; the second year it throws out branches. A valuable commercial class, extra hardy, resists droughts. This was found growing on pure sand which dries to a powder eight months of the year.

All of the above (S. P. I. Nos. 23864 to 23866) are from the Coast Cordilleras about 35 to 40 miles from the sea, are readily eaten by all animals; extra hardy.

23867. CHUSQUEA QUILA (Poir.) Kunth.**Bamboo.**

Quila. A long-leaf-stem class about 20 feet long; grows drooping.

23868. CHUSQUEA QUILA (Poir.) Kunth.**Bamboo.**

Quila. A drooping class whose short leaves grow in bunches close to the stem from each joint. When the leaves are eaten they quickly grow again and also sprout anew. A good forage class. From 10 to 20 feet long.

23869. CHUSQUEA QUILA (Poir.) Kunth.

Quila. Similar to S. P. I. No. 23867 in leaf; plant somewhat dwarfed; grows from 6 to 12 feet long.

All of the above (S. P. I. Nos. 23867 to 23869) are from the Coast Cordilleras about 40 miles from the sea, are extra hardy and grow dry in poorest arid soils.

23870. RUBUS PANICULATUS Smith.**Raspberry.**

From Jaunsar District, Chakrata U. P., India. Presented by Mr. H. G. Billson, Deputy Conservator of Forests, requested by Mr. David Fairchild at the suggestion of Mr. Henry M. Dumbleton, Victoria, British Columbia. Received October 13, 1908.

"This 'blue raspberry' grows sparingly in the forests in the Jaunsar District. The bush is small and trailing; the fruit is about the size of a logan berry, but with a beautiful blue bloom, and is excellent eating." (*Dumbleton.*)

"This raspberry is the 'Kala Anchu.' It grows best below 6,000 feet and likes damp, shady ravines." (*Billson.*)

23871. MEDICAGO SATIVA L.**Alfalfa.**

From Elche, Spain. Presented by Dr. L. Trabut, government botanist, Algiers, Algeria, through Mr. Charles J. Brand. Received February 14, 1908.

"This sample of alfalfa was grown at Elche, Spain, where Doctor Trabut personally collected it. It has unusually large leaves and Doctor Trabut regards it as being distinct from Algerian alfalfa." (*Brand.*)

23872 to 23881.

From Paris, France. Presented by Mr. E. Tisserand, Minister of Colonies, Jardin Colonial. Received October 4, 1908.

The following plants:

23872 to 23874. *MUSA PARADISIACA* L.

Banana.

23872. *Chec Chwea* (Cambodia).

23873. *Primitivo* (Colombia).

23874. *Gabou* (Réunion).

23875. *MUSA CAVENDISHII* Lamb.

Banana.

Sweet (New Caledonia).

23876 and 23877. *COLOCASIA ESCULENTA* (L.) Schott.

23876. Green.

23877. Violet.

23878. *BOMBAX MACROCARPUM* (Cham. & Schlecht.) Schum.

23879. *PASSIFLORA LAURIFOLIA* L.

23880. *PASSIFLORA* sp.

(Mexico.)

23881. *AMORPHOPHALLUS BULBIFER* (Roxb.) Blume.

23882. *GARCINIA CORNEA* L. (?)

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received October 15, 1908.

"The *Garcinia cornea* L. is a small tree, with horizontal branches; leaves, leathery, shining. Fruit the size of a small orange, bright red; seeds inclosed in a white, juicy, very acid aril." (*Hooker, Flora of British India.*)

"An evergreen tree; yields an inferior kind of gamboge; wood brown, heavy, of a coarse unequal fiber, hard, rather close grained." (*Watt, Economic Products of India.*)

"Imported for use in solving the mangosteen problem." (*Fairchild.*)

23894 and 23895. *RUBUS CHAMAEMORUS* L.

From Harrington Harbor, Canadian Labrador. Presented by Miss Edith Mayon, Deep Sea Mission Hospital. Received October 17, 1908.

"Plants and fruits of what is locally called the *Bake apple*; it resembles a yellow raspberry in color and size, tastes of honey and bananas mixed, grows in moist ground on a plant 4 inches high; the flower is white. It is very hardy, for our winters are long and severe, the surface of the ground is still frozen (May 26) and there is snow in all the hollows and shady places." (*Mayon.*)

23896. *MEDICAGO SATIVA* L.

Alfalfa.

From Lima, Peru. Presented by Señor Ignacio La Puente, through Mr. Charles J. Brand. Received September, 1908.

"This seed probably originated in the vicinity of Supe, in the coastal plain region of Peru." (*Brand.*)

23897. *CRYPTOCARYA RUBRA* (Mol.) Skeels. (*PEUMUS RUBRA* MOL. SAGG. CHIL. 185. 1782.) (*CRYPTOCARYA PEUMUS* NEES.)

From Coronel, Chile. Presented by Mr. Teodoro Finger, Estación Colico, through Mr. O. W. Barrett. Received October 20, 1908.

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23897—Continued.

"A beautiful Chilean tree, persistent leaves, produces a small pink fruit of the size of a small olive; natives eat the fruit after boiling it. Very ornamental when fruits are ripe. Requires wet soil, can stand frost, grows best in valley protected from wind, in forests." (*Finger.*)

23899. UVARIA RUFA (Dun.) Blume.

From Pampanga, Philippine Islands. Presented by Mr. William S. Lyon, Gardens of Nagtajan, Manila, P. I. Received October 20, 1908.

"Small evergreen fruit tree, from sea level up to 2,000 feet, lat. 10½° S. to 16° N. Fruits oblong (5 cm. × 3 cm.) in grape-like clusters, 10 to 30 berries. These are edible and fairly palatable. Intense vermilion red, making tree in fruit very attractive." (*Lyon.*)

23900. ACTINIDIA ARGUTA (S. & Z.) Planch. (?)

From Marblehead, Mass. Received October 21, 1908.

"From a 20-year-old vine on the place of Mr. Charles N. Parker, Marblehead, Mass. This vine has borne fruit regularly since it was 8 to 9 years old, and I saw fruit on it. There can be no doubt, therefore, that it is the female variety and a good bearer. The fruit is of delicate flavor." (*Fairchild.*)

23901. CECROPIA PELTATA L.

From Kingston, Jamaica. Presented by Mr. W. Harris, superintendent, Public Gardens, Department of Agriculture, through Mr. P. J. Wester, Subtropical Garden, Miami, Fla. Received October 23, 1908.

"A variety of the urticaceous quick-growing Cecropias with edible, not very well-flavored fruits; available as a shade tree, abundant in the warmer valleys and rain-forests of Mexico. Introduced for testing at the Subtropical Garden, Miami, Fla." (*Chisolm.*)

23902. MEDICAGO SATIVA L.**Alfalfa.**

From Peru. Presented by Mr. T. F. Sedgwick, Lima, Peru, for Mr. C. V. Piper. Received October 6, 1908.

San Pedro.

23913. PINUS DENSIFLORA Sieb. & Zucc.**Pine.**

From near Tungling, Chihli, China. Received through Mr. Frank N. Meyer, agricultural explorer, summer of 1908.

"(No. 1172a, Nov. 29-08.) This pine grows all over northern China and seems to vary a great deal." (*Meyer.*)

23914. NICOTIANA TOMENTOSA Ruiz. & Pav.

From Erfurt, Germany. Purchased from Messrs. Haage & Schmidt, at the request of Mr. A. D. Shamel. Received October 26, 1908.

"I know very little about this species, but it was purchased at Mr. George W. Oliver's suggestion in connection with our work in hybridizing tobacco. It is a very large species, with large leaves and tall stem. At present it is mainly of scientific interest, but on account of its leaf size would probably be valuable as a parent for a composite cross in regions where the yield of tobacco is the main consideration." (*J. B. Norton.*)

23915. CARICA PAPAYA L.**Papaw.**

From Singerton, near Hectorspruit, Transvaal, South Africa. Presented by Prof. J. Burt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria, Transvaal, South Africa. Received October 26, 1908.

"These seeds were procured at an altitude of 1,200 feet, subtropical climate and rather dry. The flavor was excellent, and though I can not say that it will prove superior to that of some grown in the States, it is worth trying." (*Davy.*)

23916. PHASEOLUS LUNATUS L.

From Rio Mucury, Brazil. Presented by Mr. Fred Birch, Casa do Correio, Theophilo Ottoni, Minas Geraes, Brazil. Received October 26, 1908.

"We have become acquainted with a remarkable legume here. It is a vine which grows to a length of 40 to 50 feet or more, straggling over 3 or even 4 trees of the size of orange trees. It bears its pods of (we have heard) 'most delicious' beans for 3 years in succession, and is very accommodating to a planter who is hard pressed for time, for the beans will remain good on the vine for a long time after they are ripe. Wherever the summer is hot enough, as in Florida, and there is no frost, it would thrive, I think. The only thing it wants is a fertile soil and trees to climb over. One plant will yield a large quantity of beans; on one I saw there were, I should think, 100 pods. The beans are so good that one friend said 'Everyone is mad after them.'" (*Birch.*)

23917. CARICA sp. Wild papaw.

From Upper Rio Mucury, Brazil. Presented by Mr. Fred Birch, Casa do Correio, Theophilo Ottoni, Minas Geraes, Brazil. Received October 26, 1908.

"Seed of a tree called the 'wild mamau' i. e., wild papaw, as it (the fruit) greatly resembles a papaw in shape. The tree has a large, thick, quickly tapering trunk about 2 feet 6 inches in diameter at the base and a comparatively small head, so that one is quite a remarkable object in the landscape; naturally it only grows in rich forest soil and usually on a slope. Whenever the natives find a young one in the forests they always take it home and plant it near their door, as it is in great repute as a medicine tree. They firmly believe that there is no finer remedy for anemia than its fruits. Do not forget that this fruit is a somewhat difficult one to eat. It has the strange effect of scratching the tongue and sides of throat so much as to draw blood. Whether this is due to minute spicules of flinty substance or a corrosive property of the juice I have not yet found out, but I found that when my mouth and throat had become hardened by eating 3 or 4 I could take them with impunity. The largest fruits are quite small compared to the cultivated papaw, being only 4 inches long and 1½ inches in diameter, of a bright orange color, with tender skin and of luscious appearance. The foliage is very ornamental, like horse-chestnut in miniature; it is quite striking and unlike every other forest tree here." (*Birch.*)

23918 and 23919.

From New York. Presented by Mr. George V. Nash, head gardener, New York Botanical Garden, Bronx Park, New York City, at the request of Mr. Frank N. Meyer. Received October 26, 1908.

Seed of each of the following:

23918. BERBERIS AMURENSIS Rupr.

"Stock secured from Biltmore Nursery in 1903." (*Nash.*)

"A densely branched shrub 4 to 5 feet high, quite variable, as seen in the New York Botanic Garden. At the time of my visit, early in September,

23918 and 23919—Continued.

1908, the bushes were most heavily loaded with bright scarlet berries, making them extremely ornamental. Mr. Nash said that, in his expectation, this particular variety may even replace *B. thunbergii* on account of its early and ornamental fruiting capacities." (Meyer.)

23919. LIGUSTRUM sp.

"This came to us as *Ligustrum massaloungeanum*." (Nash.)

"A remarkable privet, with rather large leaves, of dark green, glossy appearance. Grows very densely branched and is of somewhat fastigiate habit. May be of use in hybridization work when attempts are being made to create a privet combining the hardness of *L. ibota* with the leaf characteristics of *L. ovalifolium*." (Meyer.)

23920 to 23929.

From South Africa. Presented by Mr. W. C. S. Paine, through Mr. W. D. Warne, Cecil Hotel, Umtali, Rhodesia, South Africa. Received July 20, 1908.

Seed of each of the following:

- 23920.** ERAGROSTIS sp.
- 23921.** ERAGROSTIS sp.
- 23922.** BAMBOS (?).
- 23923.** TRISTACHYA BISERIATA Stapf.
- 23924.** TRISTACHYA REHMANNI Hack.
- 23925.** POGONARTHRIA FALCATA (Hack.) Rendle.
- 23926.** PANICUM SERRATUM (Thunb.) R. Br.
- 23927.** THEMEDA FORSKALII Hack.
- 23928.** ANDROPOGON RUFUS (Nees) Kunth. (?)
- 23929.** ANDROPOGON PLEIARTHRON Stapf. (?)

"The above selection I made from veldt cattle favor, although I can not claim to state with any authority the specific value of the grasses. The soil is dioritic, a sandy loam, varying in color from pinkish red, deep red, and chocolate." (Paine.)

23930 to 24113.

From China. Brought by Mr. Frank N. Meyer, agricultural explorer, direct from China. Turned over to this office to be numbered for distribution October, 1908.

The following seeds:

23930. ASTRAGALUS SINICUS L.

"(No. 986a, May 31, 1908.) A few seeds of a most important leguminous plant, which is grown and plowed under for manure on low-lying rice fields. Sown in the autumn in rows or broadcast, plowed under in May or early June just before the rice has to be planted. According to the Chinese, is not fit as a cattle food. Collected on some bamboo boxes while en route to America aboard S. S. *Ashabula*, the soil coming from near Hangchow, Chekiang, China." (Meyer.)

23931. MEDICAGO DENTICULATA Willd.

Bur clover.

"(No. 987a, May 28, 1908.) A yellow-flowered bur clover, grown by the Chinese on low-lying rice fields as a winter crop, to be plowed under in spring, serving as manure. Mostly sown in autumn in rows or broadcast after coming up by itself. The cattle feed eagerly upon this crop. Collected on some

23930 to 24113—Continued.

bamboo boxes aboard S. S. *Ashtabula*, while en route to America, the soil coming from near Hangchow, Chekiang, China." (*Meyer*.)

23932. LAGENARIA VULGARIS Ser**Gourd.**

From Chinanfu, Shantung, China. "(No. 988a, September, 1908.) A small-fruited ornamental gourd, out of which the Chinese manufacture little carved vessels for ornaments." (*Meyer*.)

23933. CUCURBITA sp.

From Spask, eastern Siberia. "(989a, Oct. 20, 1906.) An ornamental gourd, producing remarkable quaint fruits which vary in all ways. Given to me by a Russian farmer." (*Meyer*.)

23934. CUCURBITA PEPO L.**Squash.**

From Pangshan, Chihli, China. "(No. 990a, November, 1907.) A large turban-shaped gourd, one part of which is orange-yellow colored while the other part is green with orange stripes. Quite ornamental." (*Meyer*.)

23935. CUCUMIS SATIVUS L.**Cucumber.**

From Peking, Chihli, China. "(No. 991a, Mar. 25, 1908.) A Chinese cucumber called *Huang kua*; grown on trellises in the open ground." (*Meyer*.)

23936. CUCUMIS MELO L.**Muskmelon.**

From Peking, Chihli, China. "(No. 992a, Mar. 25, 1908.) A small muskmelon; grown on light sandy soil. Chinese name *Hsien kua*." (*Meyer*.)

23937. LUFFA CYLINDRICA (L.) Roemer.

From Peking, Chihli, China. "(No. 993a, Mar. 25, 1908.) A dishrag gourd, the tender young fruits of which are eaten by the Chinese. Chinese name *Shi kua*." (*Meyer*.)

23938. BENINCASA CERIFERA Savi.**Gourd.**

From Peking, Chihli, China. "(No. 994a, Mar. 25, 1908.) A gourd eaten by the Chinese. Chinese name *Tung kua*." (*Meyer*.)

23939. ACTINOSTEMMA sp.

From Peking, Chihli, China. "(No. 995a, Mar. 25, 1908.) A very rare cucurbitaceous plant, called in Chinese *Ly kua tze*." (*Meyer*.)

23940 to 23945. LAGENARIA VULGARIS Ser.**Gourd.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23940. "(No. 996a.) Chinese name *Yang hu lu*."

23941. "(No. 997a.) Chinese name *Yoh hu lu*."

23942. "(No. 998a.) Chinese name *Ko ko hu lu*."

23943. "(No. 999a.) Chinese name *Shoo yar yow hu lu*."

23944. "(No. 1000a.) Chinese name *Ta yar yow hu lu*."

23945. "(No. 1001a.) Chinese name *Ta paww ku lu*."

"The above *Lagenarias* are grown by the Chinese on trellises in their gardens; the very young fruits are often eaten stewed as a vegetable; the old, well-ripened gourds are used as bottles for oil, wine, and water, or when cut in two lengthwise are used for water dippers and for pans in which to keep things. The large round gourds serve the country Chinese for the same purpose as our drawers in cupboards do, viz, to keep things stored in; and lastly these *Lagenaria* seeds are often boiled with salt and sold as an appetizing delicatessen." (*Meyer*.)

23930 to 24113—Continued.**23946 to 23952. CUCURBITA PEPO L.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23946. "(No. 1002a.) Chinese name *San kua*."

23947. "(No. 1003a.) Chinese name *Nan kua*."

23948. "(No. 1004a.) Chinese name *Tau nan kua*."

23949. "(No. 1005a.) Chinese name *Tchoo tze kua*."

23950. "(No. 1006a.) Chinese name *Ba loeng woo kua*."

23951. "(No. 1007a.) Chinese name *Shi bin woo kua*."

23952. "(No. 1008a.) Chinese name *Hsi hu kua*."

"The above numbers include pumpkins and squashes and are used by the Chinese as vegetables, either stewed or boiled. The seeds too are roasted or boiled in salted water and then dried. The plants are mostly grown between corn, sorghum, and other tall-growing crops, sometimes even on rather alkaline soil." (*Meyer*.)

23953 to 23956. DOLICHOS LABLAB L.**Bonavist bean.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23953. "(No. 1009a.) Chinese name *Lung tsao pian doh*. Black colored."

23954. "(No. 1010a.) Chinese name *Tze pian doh*. Black colored."

23955. "(No. 1011a.) Chinese name *Ching pian doh*. Brown colored."

23956. "(No. 1012a.) Chinese name *Pai pian doh*. White colored."

"All the above hyacinth [bonavist] beans are grown by the Chinese against sorghum-stem fences and between sorghum and corn crops, in which case they use the stems of these last-named plants for their support. The pods when green and juicy are sliced and eaten boiled as a vegetable; the leaves when dry are boiled in soups and considered a rather expensive food." (*Meyer*.)

23957. PHASEOLUS COCCINEUS L.**Scarlet runner bean.**

From Peking, Chihli, China. "(No. 1013a, Mar. 25, 1908.) The scarlet runner is grown sparsely in northern China against fences of sorghum stems and on poles, apparently for ornament, though the fresh pods are sliced and eaten boiled and the dry beans are sometimes cooked in soups. Chinese name *Hua pian doh*." (*Meyer*.)

23958. PHASEOLUS VULGARIS L.

From Peking, Chihli, China. "(No. 1014a, Mar. 25, 1908.) A form of garden bean, loving a rich garden soil, but being able to stand much alkali. The young pods are eaten boiled as a vegetable; the dry beans are cooked in soups. Chinese name *Yueng pian doh*." (*Meyer*.)

23959. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

From Peking, Chihli, China. "(No. 1015a, Mar. 25, 1908.) A long string bean, the pods of which are eaten boiled as a vegetable. Has to be grown on stakes and is remarkably productive. Chinese name *Chiang doh*." (*Meyer*.)

23960. ABRUS PRAECATORIUS L.

From Peking, Chihli, China. "(No. 1016a, Mar. 25, 1908.) The paternoster bean; grown by the Chinese for medicine and for ornament, namely, they manufacture beads and bracelets of the seeds by stringing them on strong threads. Chinese name *Yae ho hua*." (*Meyer*.)

23930 to 24113—Continued.**23961. RICINUS COMMUNIS L.****Castor oil bean.**

From Peking, Chihli, China. "(No. 1017a, Mar. 25, 1908.) The castor oil bean which is grown all over China, the oil being used for culinary purposes, viz, all the doughnuts and small cakes which the Chinese eat for breakfast are fried in it, and it seems to lose its peculiar medicinal properties after having been heated. Chinese name *Ta ma tze*." (Meyer.)

23962. COIX LACRYMA-JOBI L.**Job's tears.**

From Peking, Chihli, China. "(No. 1018a, Mar. 25, 1908.) The well-known Job's tears, seeds of which are used for ornaments. Chinese name *Tsao choo tze*." (Meyer.)

23963 and 23964. BRASSICA PEKINENSIS (Lour.) Skeels. (SINAPIS PEKINENSIS Lour.) (BRASSICA PETSAL Bailey.)**Chinese cabbage.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23963. "(No. 1019a.) Chinese name *Boo to pai tsai*."

23964. "(No. 1020a.) Chinese name *Shoo pai tsai*."

"Sow the cabbages at the end of July or early in August, transplant in early September in well-worked and heavily manured soil. Do not let them suffer from lack of water. Harvest after the first heavy frost and store away in a cool, frostproof cellar. Will do especially well in the irrigated sections of the United States." (Meyer.)

23965. BRASSICA JUNCEA (L.) Cass.**Chinese mustard.**

From Peking, Chihli, China. "(No. 1021a, Mar. 25, 1908.) Grown as an early vegetable for greens, being sown very early in spring in a well-worked, light, warm soil. Pulled up and sold in bunches; also picked for private use. Chinese name *Yi tsai*." (Meyer.)

23966. BRASSICA RAPA L.**Turnip.**

From Peking, Chihli, China. "(No. 1022a, Mar. 25, 1908.) Probably a long, white spring turnip. As such, grow it in light, well-worked soil. Sow in rows as early as possible in a protected place. The turnips stewed with milk form a good dish in the early summer. Chinese name *Pien lang*." (Meyer.)

23967. RAPHANUS SATIVUS L.**Radish.**

From Peking, Chihli, China. "(No. 1023a, Mar. 25, 1908.) A red variety. Sow in hills, distance $1\frac{1}{2}$ feet apart, in early August, on well-drained soil. Harvest before heavy frost. Store in cellar for winter use. Eaten stewed like turnips. Chinese name *Tung lung hong lou ba*." (Meyer.)

23968 and 23969. RAPHANUS SATIVUS L.**Radish.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23968. "(No. 1024a.) Chinese name *Tsui lou poo* (green radish-turnip)."

23969. "(No. 1025a.) Chinese name *Hong sweet lou poo* (red radish-turnip)."

"These peculiar roots are largely eaten by the Chinese as appetizers and really are very pleasing to the taste and promote digestion. Sow in early August in well-drained soil, in hills $1\frac{1}{2}$ feet apart in each direction. Harvest before a heavy frost and store in cool cellars for winter use. Always eaten raw and sliced lengthwise." (Meyer.)

23930 to 24113—Continued.**23970. APIUM GRAVEOLENS L.****Celery.**

From Peking, Chihli, China. "(No. 1026a, Mar. 25, 1908.) A Chinese variety of celery, much used in soups and in various other dishes, although quite strong. May contain more of the active alkaloids than our own varieties and be of use in celery-salt manufacture. Chinese name *Hu dien mae hua*." (Meyer.)

23971. DAUCUS CAROTA L.**Carrot.**

From Peking, Chihli, China. "(No. 1027a, Mar. 25, 1908.) A Chinese carrot. Sow in rows in somewhat sandy though rich soil. Do not let them have any lack of water. Chinese name *Hu lou poo*." (Meyer.)

23972. CORIANDRUM SATIVUM L.

From Peking, Chihli, China. "(No. 1028a, Mar. 25, 1908.) A well-known herb, the young leaves of which are used by the Chinese to flavor their soups with. The seeds are also used in various kinds of candy. Chinese name *Hsien tsai*." (Meyer.)

23973. LACTUCA SATIVA L.**Lettuce.**

From Peking, Chihli, China. "(No. 1029a, Mar. 25, 1908.) A Chinese lettuce which does not form a head, but the stems get to be quite fleshy and are stewed like asparagus. Quite tasty. Chinese name *Sun tsai*." (Meyer.)

23974. BETA VULGARIS L.**Beet.**

From Peking, Chihli, China. "(No. 1030a, Mar. 25, 1908.) Probably a red beet root, the young leaves of which are eaten stewed and also the roots when about full grown. This is inferior to our own varieties. Chinese name *Hong pai tsai*." (Meyer.)

23975. CAPSICUM ANNUUM L.**Pepper.**

From Peking, Chihli, China. "(No. 1031a, Mar. 25, 1908.) A Chihli pepper grown by the Chinese partly for ornament and partly for condiments. Chinese name *Shi tze cheew*." (Meyer.)

23976. SOLANUM MELONGENA L.**Eggplant.**

From Peking, Chihli, China. "(No. 1032a, Mar. 25, 1908.) An eggplant which may turn out to be more ornamental than useful. Chinese name *Chieng yen chi*." (Meyer.)

23977 to 23983. CELOSIA ARGENTEA L.

From Peking, Chihli, China. (Mar. 25, 1908.)

23977. "(No. 1033a.) Chinese name *Hong gee kuan hua*."

23978. "(No. 1034a.) Chinese name *Huang gee kuan hua*."

23979. "(No. 1035a.) Chinese name *Huang shoo gee kuan hua*."

23980. "(No. 1036a.) Chinese name *Tze shoo gee kuan hua*."

23981. "(No. 1037a.) Chinese name *Hong shoo gee kuan hua*."

23982. "(No. 1038a.) Chinese name *Pai shoo gee kuan hua*."

23983. "(No. 1039a.) Chinese name *Kuan shang chiar kuan*."

"The above forms are grown by the Chinese as ornamental garden plants." (Meyer.)

23984 to 23988. AMARANTHUS spp.

From Peking, Chihli, China. (Mar. 25, 1908.)

23984. "(No. 1040a.) Chinese name *Lo lie show*."

23985. "(No. 1041a.) Chinese name *Hong doo chuang hua*."

23930 to 24113—Continued.**23984 to 23988—Continued.**

23986. "(No. 1042a.) Chinese name *Sen doo chuang hua*."

23987. "(No. 1043a.) Chinese name *Tze doo chuang hua*."

23988. "(No. 1044a.) Chinese name *Pai doo chuang hua*."

"The above plants are grown by the Chinese in their gardens as summer annuals." (*Meyer.*)

23989. PAPAVER SOMNIFERUM L.**Poppy.**

From Peking, Chihli, China. "(No. 1045a, Mar. 25, 1908.) A poppy grown for its ornamental flowers in gardens in North China. Chinese name *Hong ye'n swee hua*." (*Meyer.*)

23990 to 23992. PAPAVER RHOEAS L.**Poppy.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23990. "(No. 1046a.) Chinese name *Hong yii mie ren hua*."

23991. "(No. 1047a.) Chinese name *Pai yii mie ren hua*."

23992. "(No. 1048a.) Chinese name *Ten yii mie ren hua*."

"These flowering poppies are grown by the Chinese as ornamental garden annuals. Sow early." (*Meyer.*)

23993 and 23994. CASSIA OCCIDENTALIS L.

From Peking, Chihli, China. (Mar. 25, 1908.)

23993. "(No. 1049a.) Chinese name *Huang whee tze*."

23994. "(No. 1050a.) Chinese name *Sing huang whee tze*."

"The above are grown by the Chinese as ornamental garden plants." (*Meyer.*)

23995 to 23999. POLYGONUM ORIENTALE L.**Prince's-feather.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23995. "(No. 1051a.) Chinese name *Swee ping hua*."

23996. "(No. 1052a.) Chinese name *Pai mow dan*."

23997. "(No. 1053a.) Chinese name *Hong mow dan*."

23998. "(No. 1054a.) Chinese name *Tze mow dan*."

23999. "(No. 1055a.) Chinese name *Ten mow dan*."

"All the foregoing varieties of prince's-feather are cultivated by the Chinese of North China in their gardens as ornamental plants. The colors of the bracts range from pure white to dark red. Plants are able to stand alkali very well and may be of use in the Western States." (*Meyer.*)

24000. HIBISCUS sp.

From Peking, Chihli, China. "(No. 1056a, Mar. 25, 1908.) An ornamental plant grown in gardens in North China. Chinese name *Huang tchu kwi hua*." (*Meyer.*)

24001 and 24002. DATURA sp.

From Peking, Chihli, China. (Mar. 25, 1908.)

24001. "(No. 1057a.) Chinese name *Tze la ba hua*."

24002. "(No. 1058a.) Chinese name *Ta pai la ba hua*."

"Both of these are apparently Solanaceæ and are grown by the Chinese of North China as ornamental garden plants. They may prove to be novelties." (*Meyer.*)

23930 to 24113—Continued.**24003 to 24008. MALVA sp.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24003. "(No. 1059a.) Chinese name *Hong shoo show gee*."

24004. "(No. 1060a.) Chinese name *Ten shoo show gee*."

24005. "(No. 1061a.) Chinese name *Pai shi gee hai tang*."

24006. "(No. 1062a.) Chinese name *Lang shi gee hai tang*."

24007. "(No. 1063a.) Chinese name *Hong shi gee hai tang*."

24008. "(No. 1064a.) Chinese name *Pai shi gee hai tang*."

"The above are grown by the Chinese of North China as ornamental garden plants." (Meyer.)

24009 to 24016. ALTHAEA ROSEA (L.) Cav.**Hollyhock.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24009. "(No. 1065a.) Chinese name *Huang ta show gee*."

24010. "(No. 1066a.) Chinese name *Lang ta show gee*."

24011. "(No. 1067a.) Chinese name *He ta show gee*."

24012. "(No. 1068a.) Chinese name *Sen ta show gee*."

24013. "(No. 1069a.) Chinese name *Pou ta show gee*."

24014. "(No. 1070a.) Chinese name *Tze ta show gee*."

24015. "(No. 1071a.) Chinese name *Hong ta show gee*."

24016. "(No. 1072a.) Chinese name *Moo ho ta show gee*."

"The hollyhocks are favorite garden plants with the Chinese of North China, thriving well in the semiarid climate of northeast Asia. Among these preceding numbers there is one said to be black, No. 1067a (S. P. I. No. 24011), but in all probability the seeds will appear to be very much mixed, as with nearly all seeds to be had in China. There may be hardier and more disease-resistant varieties than those we possess at present among this lot." (Meyer.)

24017 to 24019. DATURA sp.

From Peking, Chihli, China. (Mar. 25, 1908.)

24017. "(No. 1073a.) Chinese name *Hong ba hsien hua*."

24018. "(No. 1074a.) Chinese name *Pai ba hsien hua*."

24019. "(No. 1075a.) Chinese name *Lang ba hsien hua*."

"The above are grown as ornamental plants in North China." (Meyer.)

24020 to 24029. IPOMOEA PURPUREA (L.) Roth.

From Peking, Chihli, China. (Mar. 25, 1908.)

24020. "(No. 1076a.) Chinese name *Hong la ba hua*."

24021. "(No. 1077a.) Chinese name *Huang la ba hua*."

24022. "(No. 1078a.) Chinese name *Tze la ba hua*."

24023. "(No. 1079a.) Chinese name *Pai la ba hua*."

24024. "(No. 1080a.) Chinese name *Sen la ba hua*."

24025. "(No. 1081a.) Chinese name *Lang la ba hua*."

24026. "(No. 1082a.) Chinese name *Hua la ba hua*."

24027. "(No. 1083a.) Chinese name *Luo ching la ba hua*."

24028. "(No. 1084a.) Chinese name *Noo ho la ba hua*."

24029. "(No. 1085a.) Chinese name *Shoo hong hua*."

23930 to 24113—Continued.**24020 to 24029—Continued.**

"The above are in all probability different varieties of *Ipomoea purpurea*; grown by the Chinese in North China as ornamental garden climbers against fences and walls. There are said to be all kinds of colors among these, but the seeds are probably very much mixed." (Meyer.)

24030. IPOMOEA sp.

From Peking, Chihli, China. "(No. 1086a, Mar. 25, 1908.) A species of morning-glory grown in gardens in North China. Chinese name *Lang chu ling tze*." (Meyer.)

24031. IPOMOEA sp.

From Peking, Chihli, China. "(No. 1087a, Mar. 25, 1908.) Chinese name *Hu lu pian doh*, which name may be fictitious, as *pian doh* is the name for *Dolichos lablab*. This *Ipomoea* is grown like the rest of the morning-glories as an ornamental garden vine." (Meyer.)

24032. IRIS ENSATA Thunb. (?)

From Peking, Chihli, China. "(No. 1088a, Mar. 25, 1908.) Apparently an Iris, grown as an ornamental plant in gardens in North China. Chinese name *Shir yong chieng*." (Meyer.)

24033 to 24044. MIRABILIS JALAPA L.**Four-o'clock.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24033. "(No. 1089a.) Chinese name *Luaun hong mu lee*."

24034. "(No. 1090a.) Chinese name *Luaun huang mu lee*."

24035. "(No. 1091a.) Chinese name *Luaun pai mu lee*."

24036. "(No. 1092a.) Chinese name *Luaun sen mu lee*."

24037. "(No. 1093a.) Chinese name *Luaun tze mu lee*."

24038. "(No. 1094a.) Chinese name *Luaun hua mu lee*."

24039. "(No. 1095a.) Chinese name *Huang mu lee hua*."

24040. "(No. 1096a.) Chinese name *Lang mu lee hua*."

24041. "(No. 1097a.) Chinese name *Pai mu lee hua*."

24042. "(No. 1098a.) Chinese name *Sen mu lee hua*."

24043. "(No. 1099a.) Chinese name *Hong mu lee hua*."

24044. "(No. 1100a.) Chinese name *Tchung tze hu mu lee hua*."

"These twelve preceding numbers are varieties of the ordinary four-o'clock, which is a great favorite with the Chinese of North China. They are able to stand considerable alkali in the soil." (Meyer.)

24045 to 24058. IMPATIENS BALSAMINA L.**Balsam.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24045. "(No. 1101a.) Chinese name *Lang ting tung*."

24046. "(No. 1102a.) Chinese name *Sen ting to tung*."

24047. "(No. 1103a.) Chinese name *Hong ting to tung*."

24048. "(No. 1104a.) Chinese name *Tze ting to tung*."

24049. "(No. 1105a.) Chinese name *Pai ting to tung hua*."

24050. "(No. 1106a.) Chinese name *Suo ching ting to tung hua*."

24051. "(No. 1107a.) Chinese name *Hua pien ting to tung hua*."

24052. "(No. 1108a.) Chinese name *Moo ho ting to tung hua*."

24053. "(No. 1109a.) Chinese name *Hong lung tsao tung hsien hua*."

23930 to 24113—Continued.

24045 to 24058—Continued.

24054. "(No. 1110a.) Chinese name *Hua lung tsao tung hsien hua*."
 24055. "(No. 1111a.) Chinese name *Tze lung tsao tung hsien hua*."
 24056. "(No. 1112a.) Chinese name *Lang lung tsao tung hsien hua*."
 24057. "(No. 1113a.) Chinese name *Pai lung tsao tung hsien hua*."
 24058. "(No. 1114a.) Chinese name *Lang hua pien lung tsao tung hsien hua*."

"All the preceding numbers are apparently varieties of the ordinary balsam, which is much grown by the Chinese as an ornamental summer annual, mostly in boxes and earthen vessels. There are some fine varieties among them, and as a whole they may prove to be somewhat hardier than our own strains." (Meyer.)

24059 to 24062. (Undetermined.)

From Peking, Chihli, China. (Mar. 25, 1908.)

24059. "(No. 1115a.) Chinese name *Ta nai kong*."
 24060. "(No. 1116a.) Chinese name *Pai nai kong*."
 24061. "(No. 1117a.) Chinese name *Hong sho yo*."
 24062. "(No. 1118a.) Chinese name *Sun kuan moo*."

"These four numbers represent apparently a *Salvia* or some closely allied genus of *Menthaceae*; they are grown by the Chinese as ornamental garden plants." (Meyer.)

24063 to 24066. *DIANTHUS CHINENSIS* L.

Chinese pink.

From Peking, Chihli, China. (Mar. 25, 1908.)

24063. "(No. 1119a.) Chinese name *Hong shir chow*."
 24064. "(No. 1120a.) Chinese name *Ten shir chow*."
 24065. "(No. 1121a.) Chinese name *Tze shir chow*."
 24066. "(No. 1122a.) Chinese name *Pai shir chow*."

"The above are apparently different varieties of Chinese pinks, which are favorite plants in Chinese gardens." (Meyer.)

24067 to 24069. (Undetermined.)

From Peking, Chihli, China. (Mar. 25, 1908.)

24067. "(No. 1123a.) Chinese name *Hong wan sho chii hua*."
 24068. "(No. 1124a.) Chinese name *Pai wan sho chii hua*."
 24069. "(No. 1125a.) Chinese name *Huang wan sho chii hua*."

"Grown as an ornamental garden plant in North China." (Meyer.)

"These seeds belong to a species of *Asteraceae*." (H. C. Skeels.)

24070. *HELIANTHUS* sp.

From Peking, Chihli, China. "(No. 1126a, Mar. 25, 1908.) Apparently a *Helianthus* or a closely allied composite. Grown as an ornamental garden plant in North China. Chinese name *Hong mi lou sung*." (Meyer.)

24071 to 24073. *HELIANTHUS ANNUUS* L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24071. "(No. 1127a.) Chinese name *Huang kui hua*."
 24072. "(No. 1128a.) Chinese name *Checoo lien tung*."

23930 to 24113—Continued.**24071 to 24073—Continued.**

24073. "(No. 1129a.) Chinese name *Tsau yang hua*."

"These sunflower varieties are cultivated in China for their seeds, which are eaten as a delicatessen; for their leaves, which are fed to domestic animals; and for their stalks, which are used for fuel." (*Meyer*.)

24074 and 24075. CHRYSANTHEMUM CORONARIUM L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24074. "(No. 1130a.) Chinese name *Hoow tze kang*."

24075. "(No. 1131a.) Chinese name *Yae liè hsien*."

"The above are grown by the Chinese in North China as ornamental garden plants." (*Meyer*.)

24076 to 24078. CRASSINA ELEGANS (Jacq.) Kuntze.**Zinnia.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24076. "(No. 1132a.) Chinese name *Hong chung mae hua*."

24077. "(No. 1133a.) Chinese name *Huang chung ye mae hua*."

24078. "(No. 1134a.) Chinese name *Pai mu sié mae hua*."

"The above are apparently varieties of *Crassina elegans*, which is grown sparsely as a garden plant in North China." (*Meyer*.)

24079 to 24081. CALENDULA OFFICINALIS L.**Marigold.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24079. "(No. 1135a.) Chinese name *Ten hsi fan lien*."

24080. "(No. 1136a.) Chinese name *Hong hsi fan lien*."

24081. "(No. 1137a.) Chinese name *Chung tsaién tze hua*."

"The above are varieties of the ordinary marigold, grown as an ornamental garden plant in North China." (*Meyer*.)

24082 to 24085. TAGETES ERECTA L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24082. "(No. 1138a.) Chinese name *Hung chií hua*."

24083. "(No. 1139a.) Chinese name *Hong chií hua*."

24084. "(No. 1140a.) Chinese name *Hong fu jung hua*."

24085. "(No. 1141a.) Chinese name *Huang fu jung hua*."

"The above are apparently varieties of *Tagetes erecta* or a form closely allied to it. They are grown as ornamental garden annuals by the Chinese of North China." (*Meyer*.)

24086. LACTUCA SATIVA L. (?)

From Peking, Chihli, China. "(No. 1142a, Mar. 25, 1908.) A composite. Grown as an ornamental garden plant in North China. Chinese name *Hong kwei hua*." (*Meyer*.)

24087 to 24109. CALLISTEMMA CHINENSIS (L.) Skeels. (ASTER CHINENSIS L.) (CALLISTEPHUS CHINENSIS Nees.)**China aster.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24087. "(No. 1143a.) Chinese name *Huang Chiang hsi la hua*."

24088. "(No. 1144a.) Chinese name *Lang Chiang hsi la hua*."

24089. "(No. 1145a.) Chinese name *Hwei Chiang hsi la hua*."

24090. "(No. 1146a.) Chinese name *Hua Chiang hsi la hua*."

23930 to 24113—Continued.**24087 to 24109—Continued.**

24091. "(No. 1147a.) Chinese name *Tze Chiang hsi la hua.*"
 24092. "(No. 1148a.) Chinese name *Nan hong Chiang hsi la hua.*"
 24093. "(No. 1149a.) Chinese name *Moo ho jung tchu Chiang hsi la hua.*"
 24094. "(No. 1150a.) Chinese name *Hua yung tchu Chiang hsi la.*"
 24095. "(No. 1151a.) Chinese name *Fen yung tchu Chiang hsi la.*"
 24096. "(No. 1152a.) Chinese name *Tze yung tchu Chiang hsi la.*"
 24097. "(No. 1153a.) Chinese name *Hong yung tchu Chiang hsi la.*"
 24098. "(No. 1154a.) Chinese name *Pai yung tchu Chiang hsi la.*"
 24099. "(No. 1155a.) Chinese name *Pai hua pien Chiang hsi la.*"
 24100. "(No. 1156a.) Chinese name *Tze hua pien Chiang hsi la.*"
 24101. "(No. 1157a.) Chinese name *Chiang hsi chii.*"
 24102. "(No. 1158a.) Chinese name *Pai kwei chow chii.*"
 24103. "(No. 1159a.) Chinese name *Hong kwei chow chii.*"
 24104. "(No. 1160a.) Chinese name *Huang kwei chow chii.*"
 24105. "(No. 1161a.) Chinese name *Lang kwei chow chii.*"
 24106. "(No. 1162a.) Chinese name *Fen kwei chow chii.*"
 24107. "(No. 1163a.) Chinese name *Tze kwei chow chii.*"
 24108. "(No. 1164a.) Chinese name *Hua kwei chow chii.*"
 24109. "(No. 1165a.) Chinese name *Moo ho kwei chow chii.*"

"The above are apparently various forms and varieties of our ordinary garden aster, which is held in high esteem by the Chinese as a garden flower. There are said to be yellow-flowered varieties among this collection, but in general the seeds will be found to be very much mixed.

"As the garden aster is a native of northern Asia there may be found some types among this lot that may be of value for breeding purposes or for rather uncongenial climates." (*Meyer.*)

24110 to 24112. PANICUM MILIACEUM L.**Proso millet.**

From northern Korea. (September, 1906.)

24110. "(No. 1168a.) A white-seeded drooping millet."
 24111. "(No. 1169a.) A red-seeded drooping millet."
 24112. "(No. 1170a.) A black-seeded drooping millet."

"Apparently rare forms of millet grown by the Koreans for food. These few seeds were picked by me, while passing a few fields near the upper regions of the Tumen River and I never came across them again later on." (*Meyer.*)

24113. PANICUM sp.

From northern Korea. "(No. 1171a, September, 1906.) A millet grown on very low lying lands; used by the poor peasants, when ground up, as a gruel. Try it on low river bottoms as a late fodder crop; it stools out enormously on rich land." (*Meyer.*)

24114. ARACHIS HYPOGAEA L.**Peanut.**

From Marseille, France. Procured by Hon. Robert P. Skinner, American consul-general, at the request of Mr. W. R. Beattie and Mr. C. S. Scofield. Received October 27, 1908.

Gambia. "Pods medium size to small, light in color, closely netted, indentations quite shallow, so that the exterior surface of pods is comparatively smooth; generally two, sometimes three, and occasionally one pea in a pod; shells thin and quite firm and strong; peas medium size, one-third larger than Spanish, crowded together in pod and almost completely filling cavity, color of pea rather dark brown, outer skin adhering very tightly; flesh of pea clear white color, germ considerably extended at end of pea and easily removed.

"This pea will be exceptionally valuable for use in the manufacture of candy and other products where shelled nuts are required." (*W. R. Beattie.*)

"These peanuts were procured for testing in this country for their oil-yielding properties in comparison with the American varieties." (*R. A. Young.*)

24115 to 24121.

From Amani, German East Africa. Presented by Dr. A. Zimmerman, Biologic Agricultural Institute, at the request of Mr. C. V. Piper. Received October 23, 1908.

"The following seeds of legumes being tested here for their value as green fertilizing plants." (*Zimmerman.*)

24115. CROTALARIA sp.

24116. CROTALARIA sp.

24117. CROTALARIA sp.

24118. CROTALARIA HILDEBRANDTII Vatke.

24119. CROTALARIA STRIATA Schrank.

24120. DOLICHOS (?).

24121. INDIGOFERA (?).

24122 to 24127. ANDROPOGON SORGHUM (L.) Brot.**Kafir.**

From Greytown, Natal, South Africa. Procured from Mr. T. Thresh, "Thorn-ton," Greytown, Natal, by Mr. E. Fitzgerald, Native Affairs Department, Pietermaritzburg, Natal, presented by Mr. A. E. LeRoy, Adams, M. S., Natal. Received October 6, 1908.

Seed of the following. Descriptive notes by Mr. Carleton R. Ball; native names by Mr. LeRoy:

24122. *Mehlo ka kuka.* Blackhull kafir, apparently typical. Small head, 7 inches long; glumes, short, shiny black; seeds medium, white.

24123. *Sibuyana.* Blackhull kafir type; very compact glumes and seeds slightly larger than normal, the seeds are white with distinct brownish tinge, especially at tip.

24124. *Simuktywana.* Blackhull kafir type; head compact, very similar to preceding (S. P. I. No. 24123), but seeds more deeply tinged with brown.

24125. *Ngabani omhlope.* Kafir type of head, but seeds large; whitish or mostly pearly glumes two-thirds as long as seeds, these are greenish or, in the case of those at the base of the head, reddish brown.

24122 to 24127—Continued.

24126. *Ngabani obomru.* Red kafir, apparently typical head, shorter and more slender than normal for the United States.

24127. *U Jiba.* "The natives do not like the taste of this, but raise it because the birds do not trouble it. Birds trouble all other kinds very greatly." (*LeRoy.*)

Related to Red kafir, but with very large seeds; glumes about two-thirds as long as seeds.

24128 to 24130. ANDROPOGON SORGHUM (L.) Brot. Durra.

From Egypt. Presented by Mr. Hubert S. Smiley, Gallowhill, Paisley, Scotland. Received September 23, 1908.

Seed of the following. Descriptive notes by Mr. Carleton R. Ball; native names by Mr. Smiley:

24128. *Bahr el Bugger.* Typical durra *Ahmar* or brown-seeded durra; glumes shiny black; large seeds, pale and shiny red.

24129. *Hamashi.* "This is considered the best for bread making." (*Smiley.*)

A form apparently intermediate between durra *Ahmar* and durra *Beda* the white form; the seeds are pale brown, head is otherwise identical with durra *Ahmar*.

24130. *Heygeri.* Seeds white or brownish white; glumes shiny black and naked.

"These are typical Egyptian durras with very large and heavy ovate, extremely compact, pendant heads; the same or very similar varieties tested by me in the last few years always have immense stalks, 2 to 3 inches in diameter at the base, 8 to 13 feet high, and having from 20 to more than 30 leaves; they are mostly very late and will therefore not mature in much of our dry plain region; they are not at all adapted to the more humid region, because the compact heads become moldy in wet weather and badly injured by worms." (*Ball.*)

"This durra is sown as a rain crop in Berber, Atbara, Zeidab, and Shendi districts. Directly the rains are over, the natives go out to the borders of the desert and sow the grain on the poor, rocky soil. They then leave it, as it requires no cultivation, and it receives no more water than that left in the soil by the rains. A good crop would be about 6 ardebs per feddan. These sorghums are the principal foodstuffs of the natives." (*Smiley.*)

24131. GARCINIA sp.

From Palawan, Philippine Islands. Procured by Mr. William S. Lyon, Gardens of Nagtajan, Manila, P. I. Received November 4, 1908.

"This species is from sea level, extending from coast inland 3 to 5 kilometers only; is generally 14 to 15 meters, although sometimes larger, wide spreading and seemingly a robust grower. Fruit edible by natives, monkeys, and parrots, but I balked at much of it." (*Lyon.*)

24132. BENZOIN sp.(?)

From Mokanshan, China. Presented by Rev. J. M. W. Farnham, Shanghai, China. Received November 4, 1908.

"This shrub grows 8 or 10 feet tall. In September (here) the branches are covered thick with beautiful, very bright red berries; a bush here and there among the green shrubbery around a lawn would be pretty. Sow in the autumn, I suppose." (*Farnham.*)

24134 and 24135.

From Florida. Grown by Mr. P. J. Wester at the Subtropical Garden, Miami, Fla. Numbered for convenience in recording distribution November 9, 1908.

24134. CHRYSOPHYLLUM MONOPYRENUM Swartz.

"This belongs to the Sapotaceæ and is a native of south Florida, where it grows to a small tree, attaining sometimes a height of about 18 feet. The leaves are leathery and dark green, shining above and satiny beneath, something similar to the star apple, with which many are familiar, only this is darker and more lustrous than that species, making it more ornamental. The fruit is of no value." (*Wester.*)

24135. THESPESIA POPULNEA (L.) Soland.

"This is usually considered a native of the Old World, which has long been naturalized to the West Indies and has probably drifted with the Gulf Stream to the shores of Florida, where it grows wild on the Keys and occasionally on the mainland. This plant will attain a height here of about 20 feet or more and about the same spread under favorable conditions." (*Wester.*)

"These plants will probably be of value in southern California as ornamentals and shade trees. Both stand slight frosts." (*Wester.*)

24136. CRINODENDRON PATAGUA Mol.

From Jamaica Plain, Mass. Presented by the Arnold Arboretum. Received October 26, 1908.

"A tree attaining a height of 30 feet; pyramidal shaped; pretty foliage; very elegant, lily-shaped, drooping, red flowers." (*Dr. F. Franceschi.*)

24137 and 24138. ZEA MAYS L.**Corn.**

From Ciudad Juarez, Chihuahua, Mexico. Presented by Mr. Elmer Stearns, botanist, School of Agriculture. Received November 2, 1908.

Seed of the following:

24137. "Blue corn, is regular Aztec corn, very much used for tortillas." (*Stearns.*)

24138. "White corn, used same as above (S. P. I. No. 24137)." (*Stearns.*)

24140 to 24145.

Collected near Simla, India, in the Himalayan foothills. Presented by Mr. Evarard Cotes, Greenwood Court, Simla, India, through Mr. Frank N. Meyer. Received November 10, 1908.

Seeds of the following. Descriptive notes by Mr. Frank N. Meyer:

24140. PRUNUS ARMENIACA L.

Wild apricot.

Resembles the cultivated ones very much.

24141 to 24144. AMYGDALUS PERSICA L.

Peach.

24141. Probably an improved cultivated form.

24142. Very small pits, probably the genuine wild type.

24143. Small heart-shaped pits.

24144. The pits seem to resemble those of the *Chinese Honey* peach.

24145. PYRUS sp.

Pear.

A wild variety.

24146. ASPARAGUS FILICINUS GIRALDII C. H. Wright.

From Florence, Italy. Presented by Mr. Pasquale Bauarini, director, Orto Botanico del R. Instituto de Studi Superiori, via Romana 19. Received November 13, 1908.

"The form known in gardens as variety *Giraldii* is characterized by its large, broad, glossy, green phylloclades, usually borne in groups of five, and the solitary green flowers produced on very slender pedicels much longer than the phylloclades. The flower buds are brownish. This form has been collected in China in the Province of Shensi by Père Giraldis and in Szechwan and Hupeh by Dr. Aug. Henry.

"The species is a very variable one, and three varieties of it are enumerated in *Hooker's Flora of British India*, vi. 315, but the variety *Giraldii* has larger phylloclades than either of these." (*Charles Henry Wright, in The Gardeners Chronicle, August 15, 1908.*)

24147. MALPIGHIA GUADALAJARENSIS (Wats.) Rose.

From Ixtlan del Rio, Tepic, Mexico. Presented by Mr. Alfred Lonergan, through Mr. Frederic Chisolm. Received November 12, 1908.

"*Manzanita* or *Manzana del Cerro* (mountain apple). A low-growing tree, with small edible fruits of a taste resembling that of the apple. Grows wild on the steep, rough mountain sides in the eastern part of Tepic Territory and along the contiguous western border of the State of Jalisco, Mexico. The bark is used in tanning, and these fruits were imported to be planted at Brownsville, Tex., and Miami, Fla., to grow trees for this purpose." (*Frederic Chisolm.*)

24148 to 24154. PUNICA GRANATUM L.**Pomegranate.**

From Sidon, Syria. Procured by Mr. G. Bie Ravndal, American consul-general, Beirut, Syria, from Mohamed Effendi Dada, gardener. Received November 13, 1908.

The following cuttings:

24148. *Suneiny.*

24152. *Mawardi.*

24149. *Malissah.*

24153. *Mukl el Bagel.*

24150. *Bint el Basha.*

24154. *Seify.*

24151. *Zaffani.*

"Perhaps the most popular varieties of sweet pomegranates grown here are the *Malissah* (S. P. I. No. 24149) and the *Bint el Basha* (S. P. I. No. 24150). The *Mawardi* (S. P. I. No. 24152) is also rather sweet, but considered slightly inferior to the varieties already mentioned, so also the *Mukl el Bagel* (S. P. I. No. 24153), the latter as well as the *Zaffani* (S. P. I. No. 24151) is somewhat tart, but not as acid as the *Suneiny* (S. P. I. No. 24148). The *Seify* (S. P. I. No. 24154) is well thought of in Syria. It is found in the Damascus region, as well as in the vicinity of Sidon.

"When seeds are planted the trees will be wild and require grafting, while cuttings will produce trees of the variety of the cuttings. Pomegranates out here thrive on shade and water. Rats are very fond of the fruit and climb the trees for meals, leaving the shells of the fruit hanging quite empty." (*Ravndal.*)

24155 to 24165.

From Szechwan Province, China. Secured by Mr. E. H. Wilson, of the Arnold Arboretum, Jamaica Plain, Mass., in cooperation with this Department. Received October and November, 1908.

24155 to 24165—Continued.

The following seeds:

24155. RUBUS XANTHOCARPUS Bur. & Franch.

"(No. 806.) Subshrub 6 inches to 1 foot high; flowers white; fruits yellow, of good size and flavor. Common in abandoned cultivated areas and stony places generally in the valley of the Min River from 6,000 to 10,000 feet; abundant around the town of Sungpan. Fruit ripe July to end of August, according to altitude." (*Wilson.*)

24156. RIBES sp.

"(No. 836.) Bush 6 to 12 feet; fruit green and very acid. The common gooseberry, abundantly employed as a hedge plant around Tatienlu; altitude 8,000 to 10,000 feet." (*Wilson.*)

24157. TRITICUM AESTIVUM L.**Wheat.**

"(No. 845.) A white awnless wheat; 3 to 4 feet high; ripening in May. A common crop on the Yangtze banks, Szechwan Province." (*Wilson.*)

24158. HORDEUM VULGARE L.**Barley.**

"(No. 846.) Ordinary six-rowed barley; 2 to 3 feet high; ripening in May; cultivated in the Yangtze Valley, Szechwan." (*Wilson.*)

24159. HORDEUM sp.**Barley.**

"(No. 847.) A common six-rowed awned barley; ripe in May; abundantly cultivated on the banks of the Yangtze River, Szechwan." (*Wilson.*)

24160. TRITICUM AESTIVUM L.**Wheat.**

"(No. 848.) A red wheat; 3 to 4 feet high; ripe in May. A common crop in the Yangtze Valley, Szechwan." (*Wilson.*)

24161. HORDEUM VULGARE L.**Barley.**

"(No. 849.) A barley with purplish glumes, ripe in May; sparingly cultivated in the department of Weichon on the borders of the Chentu plain." (*Wilson.*)

24162. BRASSICA JUNCEA (L.) Cass.**Chinese rape.**

"(No. 851.) Large Chinese rape, *Ta tsai yu*; 4 to 6 feet high; abundantly cultivated throughout the Yangtze Valley and the Chentu plain." (*Wilson.*)

24163. BRASSICA sp.

"(No. 852.) Small Chinese rape, *Hsas tsai yu*; 2 to 3 feet high; not quite such a common crop as No. 851 (S. P. I. No. 24162), but very generally cultivated in Szechwan. For special use of these and all the Szechwanese economic plants, see Consul-General Hosie's report on the Province of Szechwan." (*Wilson.*)

24164. TRITICUM AESTIVUM L.**Wheat.**

"(No. 853.) A red awnless wheat; 3 feet high, with stout culms and ears; cultivated by the tribesfolk in western Szechwan and ripening in July or August, according to altitude. This wheat yields a very fine flour suitable for bread of all sorts." (*Wilson.*)

24165. FRAGARIA MOSCHATA Duchesne.

"(No. 908.) Wild strawberry. Fruit red and of very good flavor, size and shape variable, abundant around Tatienlu, 8,000 to 14,000 feet altitude." (*Wilson.*)

24166 and 24167. MELALEUCA LEUCADENDRON L.

Presented by Dr. John Gifford, Cocoanut Grove, Fla., through Mr. P. J. Wester, in charge, Subtropical Garden, Miami, Fla. Received November 17, 1908.

24166. Seed from Australia.

24167. Cuttings from a tree 18 feet tall growing near Cocoanut Grove, Fla.

"The cajaput-tree of India and Australia. Reaches a height of 80 feet. Can be grown on the edges of salt-water swamps where no Eucalyptus will survive; the tree is believed to be valuable for subduing malarial vapors like Eucalyptus. The lamellar bark is valuable for preserving fruit wrapped in it. The wood is hard, close grained, and almost imperishable underground. The leaves yield as much as 2 per cent of the well-known cajaput-oil, closely allied to that of Eucalyptus." (*Extract from Von Mueller.*)

24168 and 24169. DAHLIA spp.**Dahlia.**

From Boca del Monte, Vera Cruz, Mexico. Presented by Dr. C. A. Purpus, of Zacuapan, Mexico, through Dr. J. N. Rose, associate curator, United States National Museum. Received November 19, 1908.

Seed of the following:

24168. (Rose No. 08.314.) Flower orange or yellow.

24169. (Rose No. 08.315.) Flower purple; 6,000 to 7,000 feet altitude.

24170. MANGIFERA INDICA L.**Mango.**

From Province of Imos, Philippine Islands. Presented by Mr. Donald MacIntyre, Moanalua Gardens, Honolulu, Hawaii. Received November 20, 1908.

Pico. "A variety of merit. It comes true from seed and by that method has been reproduced in that country for generations." (*MacIntyre.*)

24172. ANONA SQUAMOSA L.**Sugar-apple.**

From Antigua, British West Indies. Presented by Mr. A. S. Archer to Mr. P. J. Wester, in charge, Subtropical Garden, Miami, Fla., who forwarded a small quantity to the Department November 9, 1908.

Variety *purpurea*.

24173 to 24192.

From Soochow, Kiangsu, China. Presented by Rev. R. A. Haden, B. D. Received November 14, 1908.

The following seeds. Quoted descriptions by Mr. Haden; descriptions of varieties by Mr. H. T. Nielsen:

24173 to 24175. VICIA FABA L.

Broad bean.

"These are varieties of the same bean, grown from about latitude 30° to 33°. They are planted in the fall; it is said that planted in the spring they will not produce. Plant 2 to 3 seeds in a hill, space about 1 foot each way. Stalk bushy and about 3 feet to 4 feet 6 inches high; foliage and seed pods quite smooth; blooms light lilac, slightly fragrant; very prolific. Among earliest plants to bloom in spring and these green beans are the earliest to be had in the market. These are cooked in the same way as butter or lima beans; when dry they are also parched and eaten, and, too, they are soaked until tender, the skin peeled off, and cooked, they are very good thus prepared."

24176. SOLANUM MELONGENA L.

Eggplant.

"A white variety of eggplant, very fine. I send these because I have never seen the white eggplant at home."

24173 to 24192—Continued.**24177 to 24179. PISUM ARVENSE L.****Field pea.**

24177. "Dark green English pea. Planted in fall with rye (October and November here). Stalk 4 to 5 feet high, branching. Flowers small, purple. Considered very prolific."

24178. "Large white English pea. Planted as above (S. P. I. No. 24177); flowers white; stalks larger and more prolific; good."

24179. "Small white. Remarks on the above (S. P. I. No. 24178) will apply to this."

24180 to 24184. GLYCINE HISPIDA (Moench) Maxim.**Soy bean.**

24180. "Plant bunchy."

Looks like *Nuttall*, No. 17253, also like No. 19183.

24181. "Large yellow soy bean, early."

24182. "Green soy bean, early."

Seed looks like *Okute*, No. 19986.

24183. "Small light green variety, early."

Seed similar to *Haberlandt*, Nos. 17263 and 19985, but is a little smaller.

24184. "Large yellow variety, medium early."

Seed looks like *Haberlandt*, No. 17271.

24185 to 24192. VIGNA UNGUICULATA (L.) Walp.**Cowpea.**

24185. "*Smallpox* cowpea. This is a variety of what in Louisiana used to be known as the cowpea; however, I never saw any there as fine as these. Rank grower; long vines, tangled and in masses; prolific fruiter."

Markings of seed like *Whippoorwill*, but shape different, having the most pronounced keel of any cowpea I have seen; shape somewhat like *Unknown*.

24186. "Large brown. Ranks in all respects with the above (S. P. I. No. 24185) except that growth is not so rank."

Shape similar to *Unknown*, but keel is longer and sharper and darker colored.

24187. "Small brown. Very prolific; splendid fodder pea."

Looks like an ordinary *Clay*, seed may be a trifle darker and smaller.

24188. "Large black-eyed spotted pea. I have not seen this growing; it was a find and is said to be very good."

Looks something like *Holstein*, but all the black except a few spots is around the hilum.

24189. "*Black*. Rank grower extensively cultivated; weevil very bad in this."

Looks like our ordinary *Black*.

24190. "*Black-Eye* cowpea, large; not as extensively cultivated as other varieties in this collection."

Looks just like our common *Black-Eye*.

24191. "*Black-Eye* cowpea, small; good."

Differs from our common *Black-Eye* only in having smaller seeds.

24192. "*Brown-Eye* cowpea, small; good."

Seed looks like our common *Brown-Eye*, but a little smaller; looks like *Brown-Eye*, No. 17855, from China.

24193. ORYZA SATIVA L.**Rice.**

From Chevy Chase, Md. Grown by Mr. David Fairchild on his place "In the Woods." Received November 23, 1908.

Grown from dry-land rice No. 19188.

"Planted June 5; it matured a crop of ripe grain. I only planted a few kernels and it received no irrigation whatever. One plant had 17 heads on it and though not as tall as irrigated rice it looks like a promising thing to me. I also planted the same variety in April and got a good stand, somewhat better than the later planting, i. e., maturing earlier. I surmise that in such seasons as the last one (1908), May would be the best time to sow this rice in Maryland." (*Fairchild.*)

24194. CARISSA CARANDAS L.

From Peradeniya, Ceylon. Presented by Mr. John C. Willis, director, Royal Botanic Gardens. Received November 21, 1908.

See No. 23750 for description.

24195. SCHOENOCAULON OFFICINALE (Schlecht.) Gray. Cebadilla.

From Vera Cruz, Mexico. Presented by Mr. William W. Canada, American consul. Received November 10, 1908.

"The party who procured some of this seed for us in 1905 informs us that it is poisonous, containing Veratrum, and is therefore generally used in the form of a tincture for destroying body lice, etc., as also ticks on cattle. There are other varieties of the same species—the *Zygadenus mexicanus* and the *Stenanthium frigidum*, but these are considered as inferior. The plant is indigenous to the soil in some parts of the State of Vera Cruz. Cebadilla is a common commodity procurable of druggists in the United States." (*Extract from letter of Consul Canada, September 18, 1905.*)

24196. CITRUS NOBILIS Lour. (?)**"Naartje."**

From Warm Baths, Transvaal, South Africa. Presented by Mr. C. A. Simmonds, at the request of Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture, Pretoria. Received November 30, 1908.

Groenskil. "The word 'Groenskil' means green skin, and the fruit of this variety bears more resemblance to the Emperor mandarin perhaps than to most others. It hangs for a long time on the trees in good condition, and is the latest ripening variety we have. It is also more hardy than the 'Platskill' (S. P. I. No. 24326)." (*Extract from letter of Mr. Davis, February 13, 1908.*) See No. 21551 for further remarks.

24197 to 24202.

From Biloxi, Miss. Grown by Prof. S. M. Tracy, special agent, who procured the original seed from Prof. C. F. Baker, Experiment Station, Santiago de las Vegas, Cuba. Received November 30, 1908.

Plants of the following; notes by Professor Tracy:

24197. CALOPOGONIUM COERULEUM (Benth.) Hemsl.

A slender vine, 10 to 15 feet, rooting freely, poor climber, nodules abundant, no flowers.

24198. CALOPOGONIUM ORTHOCARPUM Urb.

A slender vine, 3 to 6 feet, rooting freely, poor climber, nodules abundant, no flowers.

24199. GALACTIA TENUIFLORA (Willd.) W. & A.

A slender, vigorous climber, nodules abundant, no seed.

24197 to 24202—Continued.**24200.** *GALACTIA STRIATA* (Jacq.) Urb.

A slender, vigorous climber, nodules abundant, no seed.

24201. *TERAMNUS UNCINATUS* (L.) Swartz.

A dense mass of slender vines climbing poorly, nodules fair, no bloom.

24202. *BRADBURYA PLUMIERI* (Turp.) Kuntze.

A slender, thrifty climber, nodules few, no bloom.

24203. *CANANGA ODORATA* (Lam.) Hook. f. & Thoms. **Ilang ilang.**

From Lawang, Java. Presented by Mr. M. Buysman. Received December 11, 1908.

For description and other importations, see No. 22744.

24204. *CUCUMIS* sp.

From Ragaa, Bahr el Ghagel, Sudan, Africa. Presented by Mr. Hubert S. Smiley, Gallowhill, Paisley, Scotland. Received September 23, 1908.

"Seed of the *Koreish Battekh* (inedible oil pumpkin) is sown by natives among their other crops, all of which depend on rain. The oil from this pumpkin is used for cooking and other purposes, as is the better known 'semsen' oil. It is also used by the military and other officials, with the addition of tobacco juice, to protect their mules from the bite of the tse-tse fly. The oil is prepared as follows: Seeds are extracted and roasted similarly to the coffee beans; after roasting the seeds are ground up on a stove; after grinding they are thrown into a pot with oil and boiled. The oil comes to the top and is skimmed off for use." (*Smiley*.)

24205. *VICIA LEAVENWORTHII* Torr. & Gray.

From Arizona. Presented by Mr. Vernon Bailey, Bureau of Biological Survey, United States Department of Agriculture. Received December 3, 1908.

"These vetch seeds were collected September 23, 1908, at 8,500 feet altitude in the White Mountains of Arizona. The plant is abundant throughout Transition Zone, or from about 7,500 to 9,000 feet in the open yellow pine forest. It grows as a spreading bush 2 feet high and in many places covers the ground as an almost solid field of peas, loaded with fruit.

"Our horses were very fond of it and ate both pods and plant eagerly. For a week they had no other grain and ate little else, but steadily gained in flesh.

"Wild turkeys and grouse also feed on both its pods and leaves. It seems to be an unusually valuable forage plant." (*Bailey*.)

24206 to 24310.

From Chile. Received through Mr. José D. Husbands, Limávida, Chile, December 4, 1908.

The following seeds and plants; notes by Mr. Husbands:

24206 and 24207. *GREIGIA SPHACELATA* (R. & P.) Regel.**24206.** "Very spiny." (*R. A. Young*.)**24207.** "Slightly spiny." (*R. A. Young*.)**24208.** *PERSEA LINGUE* (R. & P.) Nees.

This is a very valuable industrial forest tree of large size, handsome, compact, evergreen, has glossy gray-blue-green leaves and is an extra quick grower; here it is not a delicate plant but grows quickly in any soil that is wet or very moist, also in water. The wood is light and tough like elm, but takes a very

24206 to 24310—Continued.**24208—Continued.**

high finish. Its lumber is highly esteemed and is lasting if protected from the wet; used for furniture, bodies and poles of carts, ox yokes, etc. The wood is the color of white ash, finished has a yellowish tinge, takes any stain. Its bark is solely used for tanning and is largely exported to Europe. Every station south is filled to overflowing with thousands of bags of broken bark awaiting transportation. The forests are being stripped; in a very few years this tree will be very scarce. It is an extra beautiful shade tree. Its leaves are poisonous to animals, especially sheep, who are very fond of them. Medicinally it is a powerful astringent.

24209. JUGLANS NIGRA L.**Black walnut.**

The *Bolivian* black walnut is of Bolivian origin and is a notable, majestic forest tree with handsome hanging foliage; a quick grower of great industrial value. Its wood is exploited largely in Bolivia, is a hardwood beautifully veined in dark and light grains, taking a very high finish and useful for any purpose. I have seen treelets 8 months old that measured 1 inch in diameter 3 feet from the ground, and 8 feet high. The fruit is large, abundant, and oily, but is not edible on account of its bitterness. These trees have been recently introduced into Chile and few are bearing any considerable quantity of fruit.

24210. MEDICAGO SATIVA L.**Alfalfa.**

From Huasco in the northern part of Chile. It is called by botanists *Medicago sativa*, notwithstanding it is a new and very valuable strain still unnamed. In past times both common central Chile alfalfa and "Alfalfa Peruano" were sown; this I believe to be a cross between the two which combines the merits of both and is said to be the most valuable seed known.

24211 to 24225. Stringless beans grown by irrigation:**24211 and 24212. PHASEOLUS VULGARIS L.****Bean.**

24211. Fair quality only; prolific.

24212. Very good class having large, good-flavored pods; productive.

24213. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

A curious bean, has pods from 12 to 18 inches long; "Monkey's tail."

24214 to 24225. PHASEOLUS VULGARIS L.**Bean.**

24214. "Alqueado." Very good and extra productive.

24215. Cream-colored pods, good flavor, productive.

24216. Extra superfine class, extra fine flavor, early, very prolific; a splendid bean to be eaten green.

24217. Green-colored pods, very prolific, medium quality.

24218. Early, good.

24219. "Cholos." Extra good class; extra large pods of good flavor; prolific.

24220. Early, good.

24221. Very good class.

24222. Cream-colored pod, extra early.

24223. Very good and extra productive.

24224. "Turruco." Good, prolific.

24225. Good class. Thin pod, good flavor, very prolific.

24206 to 24310—Continued.**24226 to 24228. PHASEOLUS COCCINEUS L. Scarlet runner bean.**

Beans of the Lima class used both for food and their flowers:

24226. "*Pallares*." Extra good.**24227.** Flowers bright crimson.**24228.** Flowers pink and scarlet.**24229 to 24261. PHASEOLUS VULGARIS L. Bean.****24229 to 24231.** Field beans grown dry in the poorest soil:**24229.** Grown dry but in better and more moist soil than the other samples (S. P. I. Nos. 24230 and 24231).**24230.** Grown on the coast. Yellow; prolific.**24231.** "*Chinalya*." Grown on the coast.**24232 to 24261.** Field beans. Names are unreliable; the same beans are known by different names in different sections; should there be duplicates, they are grown under such distinct conditions as to water, soil, etc., as to justify sending them:**24232.** Unknown.**24233.** Productive and extra fine.**24234.** Unknown.**24235.** Unknown.**24236.** "*Trigo*" (wheat). Irrigated, extra fine, standard class.**24237.** "*Porotos Blanco*" (white beans). Excellent class; irrigated.**24238.** "*Baya Grande*." Productive, largely sown, extra good.**24239.** "*Baya Grande Pintado*." A very good and profitable bean; irrigated.**24240.** No data. I think it would grow dry.**24241.** No name. Irrigated; extra fine table class like *Mendes*; there are two sorts in this lot.**24242.** A white class very similar to others sent. These are grown at a distance in distinct soil and conditions. Extra good.**24243.** "*Mendes Blanco*." A first-class table bean; irrigated.**24244.** Irrigated; grown in sticky black clay, extra fine table class.**24245.** "*Manteca Claro*" (light-colored lard). An extra fine class of standard table beans.**24246.** "*Coscorrones*." Extra superfine class, very productive in good soil; irrigated.**24247.** "*Bayas Oscura*" (dark bay). Largely sown for the working class.**24248.** A valuable bean in every sense.**24249.** "*Gentlemen*." A standard class, extra good; irrigated.**24250.** "*Burritos*" (little donkey). Extra good; I think the same as "*Burros Claro*" (S. P. I. No. 24260).**24251.** Irrigated; extra fine table variety.**24252.** "*Aparecido*." Largest sown and best bean in Chile for laborers. Irrigated.

24206 to 24310—Continued.**24229 to 24261—Continued.****24232 to 24261—Continued.**

24253. "*Rosillo.*" Productive and very good. Irrigated.

24254. A splendid variety for rich and poor. Swell to good size.

24255. Extra early; yellow pods; noncreeper; productive and extra good.

24256. "*Mendes.*" Irrigated. A fine table variety, extra good.

24257. "*Baya Chicha.*" Largely sown, profitable and good.

24258. "*Amarilla*" (yellow). Extra fine and very productive; a good bean.

24259. "*Aparecido Pintado.*" The largest sown and one of the best beans for the laboring classes.

24260. "*Burros Claro.*" A first-class bean, white when cooked. Irrigated. I think these are the same as "*Burritos*" (S. P. I. No. 24250).

24261. "*White Coscorrones.*" Extra superfine variety, productive in good soil. Irrigated.

24262. PISUM ARVENSE L.**Field pea.**

Exquisite flavor, sweet, medium late, prolific; white flower; extra fine variety.

24263. CYNARA SCOLYMUS L.**Artichoke.**

"*Chileno.*" Common sort.

24264. VICIA FABA L.**Broad bean.**

Very large and early.

24265. CICKER ARIETINUM L.**Chick-pea.**

"*Garbanzas.*" Grown dry in poor soil. Sown the same as beans in rows or hills.

24266. LUPINUS sp.

A papilionaceous legume which grows wild in the sands near the seacoast. Yellow flower. Might be made a food plant.

24267. LUPINUS sp.

A papilionaceous legume which grows wild in the sands near the sea. Blue flower. Said to be used roasted as a substitute for coffee, but I think it is bad for this purpose. Might be made a food plant.

24268 to 24278. CUCURBITA sp.**Squash.**

24268. Mottled skin, black and red variety; large size; very good.

24269. Mottled skin, yellow and dark green; large size; very good.

24270. Extra good variety; thick, mealy, sweet flesh; large and prolific.

24271. Extra good class, medium size; prolific; meat very thick, mealy, and extra sweet.

24272. Light drab color; large size and prolific; medium quality.

24273. Oblong shape.

24274. Yellow and drab color; medium thick and sweet flesh.

24275. Flesh color and white; thick meat.

24276. Blackish green with white stripes; thick, mealy, sweet flesh; prolific; extra good.

24206 to 24310—Continued.**24268 to 24278—Continued.****24277.** Thick, sweet flesh; productive; extra good.**24278.** White skin; thick, mealy, sweet meat; good.**24279 and 24280.** CUCURBITA PEPO L.**Pumpkin.****24279.** A distinct class of good quality, about 20 inches long and from 4 to 6 inches wide; prolific and a good keeper.**24280.** A distinct class; sweet but fibrous; grows large.**24281 to 24293.** CUCURBITA sp.**Squash.****24281.** A black-skinned variety having thick, mealy, sweet flesh; good.**24282.** Sweet, mealy, fiberless, and fleshy; good.**24283.** Greenish white tint; thick; mealy, sugar-sweet flesh, no fiber; extra good.**24284 and 24285.** (No description.)**24286.** Extra good class; medium size; thick, mealy, fiberless, extra sweet flesh; prolific.**24287.** Black skin, fine sort.**24288 to 24291.** (No description.)**24292.** A very good variety, called here tin colored; sweet, thick, fiberless flesh; large size; prolific; good keeper.**24293.** (No description.)**24294 to 24301.** CAPSICUM ANNUUM L.**Pepper.***Aji Chienno.* Various sorts in daily use; noted for their extra fine flavor. Chile gave potatoes and red peppers to the world.

Ground or pounded with stones and mixed with finely chopped onions washed in salt and water and afterwards squeezed dry and wet with vinegar, they form a delicious seasoning sauce. In cooking it is used as "color." Heat the fat or butter until it is hot enough to sputter when a drop of water is dropped into the same, put the pounded or coarsely ground peppers into the same, and leave about a quarter of a minute; then add a little cold water, the object being to extract the color and flavor of the peppers in the grease and not permit the fire to so cook the peppers as to spoil the color or make the fat bitter or of bad flavor from overcooking. This red grease is used in every kitchen to flavor all unsweetened foods. The degree of hotness is determined by the amount of grease employed. Anything fried or roasted is much improved by its use; meats, fowls, and vegetables (especially onions) fried first in "color" and afterwards made into soups, etc., are fine in flavor and attractive in appearance.

24294. Small size, hot kind.**24295.** Common variety in daily use in every house.**24296.** Common variety in general daily use.**24297.** Pepper eaten green in soups, sauces, etc.**24298.** Common hot sort.**24299.** Medium hot, common variety.**24300.** "*White Chileno*." Eaten green as a relish in soups, sauces, salads, pickles, etc., not nearly as hot as tabasco but better flavor.**24301.** "*Goat Horns*." Common variety in daily use.**24302.** SOLANUM sp.

24206 to 24310—Continued.**24303 and 24304.** *OPUNTIA FICUS-INDICA* (L.) Mill.**24303.** Fruit of this is oblong and ripens in winter; the leaf is narrow and 2 to 3 feet long.**24304.** Fruit of this ripens in midsummer; the leaves are large and thick; the thorns are very small.**24305.** *ANDROPOGON SORGHUM* (L.) Brot.**Durra.**

A food plant recently found in Chile; unknown.

"White durra with small, semicompact heads; glumes very pale and densely hairy, due probably to dry environment; seeds small, circular, and less flattened than in our domestic variety; florets awned; resembles somewhat the white durra of Syria." (*Carleton R. Ball.*)

24306. *CUCURBITA* sp.

Alcayota, vegetable marrow; used for making preserves.

24307. *CANNABIS SATIVA* L.**Hemp.**

The ordinary Chile sort; about the year 1545 it was introduced by the Spanish and has been largely grown since.

24308. *HORDEUM VULGARE* L.**Barley.**

The common Chile sort; grown on dry hills in the worst class of red clay soil; if this same seed is sown in better land it increases largely in weight and size and grows cleaner. This seed is sent as harvested and thrashed by mares.

24309. *ACACIA CAVENIA* (Mol.) Bert.

"*Espino de Chile.*" An exceedingly valuable wild thorn tree, grows abundantly throughout central Chile, seeks the driest regions, and is generally used for fences, is impassable and durable if cut when the sap is down; when green, is flexible. It is used as a fence without posts, but more generally is woven between three wires, thus making a very cheap and effective fence. The wood is red streaked with black, extra hard, is used for cogs in mill wheels, and spokes of the heaviest carts, coaches, etc., are made from it. This wood makes the best, hottest, and most lasting charcoal, used exclusively for heating dwellings. Grows quickly in worst dry soil of any class; the long taproot reaches moisture at great depths in a few months. Sheep and goats are especially fond of the new leaf growth and the seeds. The seeds are sown with the dung of these animals. They require a long soak. These trees, when cut, quickly sprout anew. Their natural shape is half round; when pruned, they grow round. It is a splendid shade tree. Leaves are very fine and beautiful. Every part of the branches blooms (the females only) early upon the naked tree before leafing, forming a dense mass of yellow flowers so deliciously fragrant that the fragrance is extracted by the Paris perfumers.

24310. *CRYPTOCARYA RUBRA* (Mol.) Skeels.

Peumo with crimson fruit.

24311. *CITRUS AURANTIUM SINENSIS* L.**Sweet orange.**

From Brazil. Presented by Mr. Pierre Paul Demers, American consul, Bahia, Brazil. Received December 11, 1908.

Bahia navel orange. "These scions were cut from very healthy orange trees, namely, the navel orange grafted upon the 'Laranja da terra.' I have eaten an orange from one of these trees measuring 15 inches in circumference, and its flavor was delicious. About one-third of these scions came from that particular tree.

24311—Continued.

"According to planters here the scions grafted upon 'Laranja da terra' give better results than those grafted upon the 'Laranja tanga.' For that reason the latter is not much used.

"These scions come from practically the only regular orange grove in this city, located at Cabula, about 3 miles from this place. The soil upon which the trees grew contains 60 per cent, more or less, of reddish clay. Navel oranges retail here for 3 and 4 cents each. They are not raised in sufficient quantities to supply the local demands, a fact which is only attributable to the laziness of the natives." (*Demers.*)

24312. VITIS VINIFERA L.**Grape.**

From Beni Abbes, Africa. Presented by Dr. L. Trabut, Mustapha, Algiers, Algeria. Received December 11, 1908.

"Large late grape. Reproduces itself from seed." (*Trabut.*)

24313. ILEX PARAGUARIENSIS St. Hil.

From Buenos Aires, Argentina. Presented by Hon. Carlos Thays, director, Government Botanical Gardens. Received December 12, 1908.

For description, see No. 3035. For previous introductions, see that number; also, Nos. 8953 and 19105.

24314 to 24325.

From De los Villares de la Reina, Salamanca, Spain. Procured by Mr. M. Fraile, of this Department, at the request of Mr. Walter T. Swingle. Received September 15, 1908.

The following seeds, descriptive notes by Mr. Fraile:

24314. PISUM SATIVUM L.**Pea.**

The common narrow-podded garden pea of Spain.

24315. VICIA MONANTHOS (L.) Desf.

This is used for making a food concentrate for animals, being ground and mixed with coarser material, such as straw and the like.

24316. LATHYRUS SATIVUS L.**Grass-pea.**

"*Muelas.*" Used both as a food and for feeding animals.

24317. AVENA SATIVA L.**Oat.**

Common variety of oats in the vicinity from which this particular sample came, near the village of De los Villares de la Reina, in the Province of Salamanca.

24318. HORDEUM VULGARE L.**Barley.**

In this particular vicinity this variety is used for feeding and not for brewing.

24319. VICIA ERVILIA (L.) Willd.**Bitter vetch.**

An unknown variety. This vetch is ground like the algarroba (S. P. I. No. 24315) and mixed with roughage as a feed for oxen.

24320. LENS ESCULENTA Moench.**Lentil.**

Used as a food and for fattening pigs.

24321. CICER ARIETINUM L.**Chick-pea.**

One of the commonest articles of food among a large proportion of the population of Spain.

24322. CICER ARIETINUM L.**Chick-pea.**

This variety is prized for its greater endurance of untoward conditions than the preceding (S. P. I. No. 24321) and giving higher yields.

24314 to 24325—Continued.**24323. TRITICUM AESTIVUM L.****Wheat.**

Candeal (white or summer). A common variety of bearded wheat used for bread making in Spain.

24324. TRITICUM DURUM Desf.**Durum wheat.**

Rubion (red). A hard, bearded wheat, said to be used to some extent in the making of macaroni and for fattening pigs.

24325. TRITICUM AESTIVUM L.**Wheat.**

Mocho. A beardless variety of wheat grown in Spain.

24326. CITRUS NOBILIS Lour. (?)**"Naartje."**

From Warm Baths, Transvaal, South Africa. Presented by Mr. C. A. Simmonds, at the request of Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture, Pretoria. Received December 14, 1908.

Platskill. "The meaning of *Platskill* is flat or smooth skin and appears also to apply to the shape of the fruit. The skin of this variety adheres closely to the segments and there is never any of the puffiness which accompanies so many varieties of mandarins. Although so closely adhering, it can be easily removed with the thumb and finger, but it is not exactly what one would call a 'kid glove' orange." (Extract from letter of Mr. Davis, dated February 13, 1908.) See No. 21551 for further remarks.

24327 to 24332. ORYZA SATIVA L.**Rice.**

From Honolulu, Hawaii. Received from Mr. F. G. Krauss, in charge of Rice Investigations, Hawaii Experiment Station, December 14, 1908.

Seed of each of the following rices, descriptive notes by Mr. Krauss:

24327. Sample of our old type Japan seed, No. 153, which has been carefully selected for some years.

24328. Variety No. 144, originally received through your Bureau as S. P. I. No. 12765. A very dwarf type of Japan seed; plant averaging less than 20 inches in height, fine foliaged and stemmed, of spreading habit, heavy tillering, 25 fruiting culms per plant; small seeded; matures in one hundred to one hundred and ten days from sowing.

24329. Variety No. 161 (*Omachi*), 24 inches to 28 inches tall; slightly spreading and inclined to lodge in heavy weather. Yields well and produces a good kernel; one hundred and ten to one hundred and twenty days to maturity. Similar to No. 153 (S. P. I. No. 24327).

24330. Variety No. 162 (*Shimokaburi*), 26 inches to 30 inches tall; of erect growth; tillers well and bears heavily; kernel not of highest type.

24331. Variety No. 165. An opaque kernel type; 36 inches to 40 inches tall; inclined to lodge; yields well; a kernel suited to the manufacture of oriental cake flours; matures one hundred and twenty days.

24332. Variety No. 163. Japan type, received by Hawaii station from Dr. G. Otsaka, Imperial Agricultural Experiment Station, Kumamoto, Japan, fall of 1907. Said to be "the most prevailing variety in the southern prefectures," there called "Shinriki" or "Sinriki."

Seed sown February 12, 1908; matured and was harvested June 25. Height 25 inches to 28 inches; fine stemmed; well foliaged; tillers well; quite spreading, but not inclined to lodge. Yields prolifically a medium small kernel of excellent quality. Recommended for further trial.

24333. TUMION CALIFORNICUM (Torr.) Greene.**California nutmeg.**

From San Francisco, Cal. Presented by Mr. Marsden Manson, Mechanics Bank Building. Received November 21, 1908.

"This is a rare and very beautiful ornamental tree, reaching a size of at least 3 to 4 feet in diameter and 50 to 75 feet in height, with handsome dark olive-green leaves, somewhat like the leaves of the large fir. It requires a deep, moist, and well-drained loam, and is a fairly rapid grower after once starting. The nuts sprout quickest if planted in a paper or straw box and carefully hulled." (*Manson.*)

24334. CERATONIA SILIQUA L.**Carob tree.**

From Miami, Fla. Received from Mr. P. J. Wester, in charge, Subtropical Garden. Received December 14, 1908.

Grown from No. 6342. See No. 3112 for description.

24335 and 24336.

From Marandellas, Rhodesia, South Africa. Presented by Mr. J. H. Finch through Mr. W. D. Warne, Umtali, Rhodesia. Received December 14, 1908.

The following seeds:

24335. ELEUSINE CORACANA (L.) Gaertn.

Ragi millet.

24336. PENNISETUM AMERICANUM (L.) Schum.

Pearl millet.

24337. THESPESIA POPULNEA (L.) Soland.

From Miami, Fla. Received from Mr. P. J. Wester, in charge, Subtropical Garden, December 16, 1908.

See No. 24135 for description.

24338. PINUS PEUCE Griseb.

From Bulgaria. Presented by Prof. C. S. Sargent, Arnold Arboretum, Jamaica Plain, Mass. Received December 17, 1908.

"This is one of the best exotic pines for the Northern States." (*Sargent.*)

24339 to 24347.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, agrostologist and botanist, Transvaal Department of Agriculture. Received December 15, 1908.

The following seeds:

24339. ANDROPOGON SORGHUM (L.) Brot.

"Variety *Roxburghii*. The dark glumes are gaping and involute at maturity; seeds much as the following (S. P. I. No. 24340) but more flinty; awned." (*Carleton R. Ball.*)

24340. ANDROPOGON SORGHUM (L.) Brot.

"Probably variety *Roxburghii*. Seeds medium size, somewhat flattened, flinty." (*Carleton R. Ball.*)

24341. VIGNA UNGUICULATA (L.) Walp.

Cowpea.

24342. PISUM ARVENSE L.

Field pea.

24343. ELEUSINE CORACANA (L.) Gaertn.

Ragi millet.

24344. SESAMUM ORIENTALE L.

Sesame.

24345. ARACHIS HYPOGAEA L.

Peanut.

24346. PHASEOLUS VULGARIS L.

Bean.

24347. ORYZA SATIVA L.

Rice.

24348. DIOSCOREA sp.**Yam.**

From Manila, Philippine Islands. Presented by Mr. W. S. Lyon. Received December 16, 1908.

"*Tongó*. This is far the best yam in existence, in my opinion, which is based upon experience with two or three of the alleged best varieties of both the East and West Indies.

"Habitat: Thin wooded or brush lands, growing in pretty stiff clay. Ripens and stays dormant in the ground from October or November until the following May." (*Lyon.*)

24349. HIPPEASTRUM sp.

From Caldera, Chile. Presented by Señor Enrique E. Gigoux. Received December 18, 1908.

"A yellow-flowered ornamental form." (*P. L. Ricker.*)

24350. BAMBOS SENANENSIS Franch. & Sav.**Bamboo.**

From Japan. Purchased from the Yokohama Nursery Company, Yokohama, Japan, through Mr. William D. Hills, agricultural explorer. Received November 27, 1908.

"Seed produced in Shinshu and Hida provinces only." (*Hills.*)

Suzu-Dake. "This bamboo also goes by the following names: *Yama-Dake*, *Mi-Suzu*, and *No-Suzu*, and in several of the provinces is often called *Hei-Jiku-Chiku*. It resembles *Kuma-Zasa* (*B. veitchii* or *B. palmata*, both of which go by this name) but is larger. The nodes are not prominent and the largest stems attain a growth of 1 sun (inch) with a stature of 10 feet and more. The leaves are 5 or 6 sun in length with a width of about 1 sun, narrower than those of the *sasa* and tapering off at the tip. Seen from a distance the tree resembles *Miscanthus sinensis* (*Xiphagrostis japonica* (Thunb.) Coville).

"*B. senanensis* grows wild on mountains and open uplands and resists the greatest extremes of cold. It spreads right into the deepest recesses and up to the highest summits of the mountains. In some places it grows and spreads over an extent of many square miles, being especially abundant at Suwa and Kiso, in the province of Shinano, and the hills of Nambu in the province of Rikuchiu.

"In China this bamboo is said to be used for making arrows. It is tough and flexible, so that crooked stems can be easily straightened, but the slender culms of those found in the Kiso Mountains are perfectly straight and well formed. They are split in half and plaited into baskets of various shapes and into mats, forming one of the products of Shinano. Where this bamboo grows wild it hinders the development of trees and obstructs the path of the mountaineer; but it is very useful for binding together the crumbling sides of declivities and for thatching the cottages of the peasantry, in mountainous parts of the country.

"Both in China and in the northern parts of Japan the young sprouts are pickled and eaten. Furthermore, the seeds of this plant and of the *sasa* furnish the poorer classes with food.

"In 1843 all the bamboos around the town of Takayama, in Hida, for a distance of many miles seeded, and the population, young and old, assembled to harvest the crop at the rate of 5 or 6 *to* (equals one-half bushel) per diem—in all, some 250,000 *koku* (the *koku* equals 5 bushels, nearly). This bamboo seed resembles wheat somewhat, both in shape and taste, the common people calling it natural rice or bamboo corn. It is eaten either parched or ground, the flour being made into small dumplings and coarse vermicelli. Chemical analyses show that the composition is the same as that of wheat or rye." (*Adapted from Satow's Cultivation of Bamboos in Japan.*) (*Walter Fischer.*)

24350—Continued.

"Introduced especially for the purpose of testing its stems in the manufacture of a matting woven for the purpose of taking the place of ordinary laths. If the stems are suitable for lath-matting purposes it may be possible to grow this bamboo profitably on steep hillsides in the South. Its use as a soil-binder is worthy of consideration, but the effect on the development of trees should be carefully considered before the plant is given a wide distribution." (*David Fairchild.*)

24351. ALEURITES MOLUCCANA (L.) Willd.**Candle nut.**

From Honolulu, Hawaii. Received through Mr. J. E. Higgins, horticulturist, Agricultural Experiment Station, December 17, 1908.

"Seeds procured for experiments in Cuba, Isle of Pines, and Porto Rico and for the expression of samples of candle-nut oil for analysis and comparison with the oils furnished by other species of the same genus.

"*Aleurites moluccana* (very generally known also under the synonym of *A. triloba*) is at home throughout Malaysia and Polynesia and has been naturalized on the tropical mainland of Asia, in Madagascar, and other tropical countries. It is abundant in the forests of New Guinea, Queensland, Samoa, Tahiti, New Caledonia, Fiji, and many of the Malayan Islands, extending to the Philippines. It is strictly an East Indian or Polynesian plant and may not originally have been native farther west than Java. The tree in its native haunts appears to prefer protected situations, being common in woods and especially in narrow valleys and gullies. It grows luxuriantly to an altitude of 3,000 feet, becoming gradually rarer to 4,000 feet, when it falls off altogether. It is a rapid grower and gross feeder, and propagates itself readily from seeds, which sprout in from 4 to 5 weeks. Its large, three-lobed leaves, silvery pubescent underneath and glossy above, make it admirably suited for shade and ornament in tropical countries, where it should be planted for its valuable seeds.

"The fruits resemble in size, and somewhat in appearance, the black walnut, with a thick fleshy rind and one or two heart-shaped seeds about the size of a horse-chestnut. The seeds or nuts are very thick shelled, containing but 33 per cent of kernel. The kernels yield approximately 60 per cent oil, making for the unshelled seeds 20 per cent of oil, which, owing to the thickness of the shells, is lower than that for *Aleurites fordii*, although the percentage of oil in the kernel is higher than in the Chinese species. The raw kernels are purgative, but are said to lose this property when roasted; so, too, the half-ripe seeds are considered of delicate flavor when eaten with salt, while the ripe ones are unwholesome. The Pacific islanders roast or cook the nuts slightly, when the shells can be broken with a light tap. The kernels are then threaded on bamboo splinters or cocoanut-leaf ribs, bound in leaves or bark, and in this way beautifully bright burning, but sooty and disagreeably smelling torches are obtained—herein the origin of the name candle nut.

"Candle-nut oil is known and sold under many names, which are used also to designate the tree or nuts which produce it: In Hawaii, kukui; in Ceylon, kekune; in India, belgaum walnut; in Jamaica, Spanish or country walnut; in the Philippines, lumbang; in French colonies, bancoul or noix de Moluques or chandelles (candle). According to Louis Edgar Andés the oil compares favorably with linseed in the durability of products made from it, but with some advantage over the latter in the rapidity with which it dries. It can consequently be used industrially for the manufacture of the same products. Its present price however—due principally, it seems, to the lack of cheap and efficient methods of shelling the nuts—does not allow it to compete with linseed. Candle-nut oil is not imported into the United States, but small quantities of the kernels find their way from Australia, various parts of Polynesia and Malaysia and the Philippines to European ports, where the oil expressed from them is used principally for soap making." (*Walter Fischer.*)

24353 to 24364.

From Chile. Received through Mr. José D. Husbands, Limávida, Chile, December 17, 1908.

The following seeds, with notes by Mr. Husbands:

24353. MEDICAGO SATIVA L.

Alfalfa.

Imported from Switzerland.

24354 to 24357. CUCURBITA sp.

Squash.

• **24354.** Extra large; good for fodder.

24355. From Curico. A good table class.

24356. From Curico. A good table class.

24357. From Rancagua. A good table class.

24358. SOLANUM TUBEROSUM L.

Potato.

"*Perhuenchas*." Named from an Indian tribe of the same name. Grown without deterioration from the beginning of colonial days.

24359. PASSIFLORA QUADRANGULARIS L.

"*Pasionaria de Ecuador*." Has an edible fruit; I think it has a blue flower. Grown in Chile.

24360. PASSIFLORA PINNATISTIPULA Cav.

"*Pasionaria de Chile*." The wild residence of this plant is in the provinces of Valparaiso and Aconcagua, near the sea. It belongs to the subgenus *Tacsonia* of *Passiflora*.

24361 to 24364. ANONA CHERIMOLA Mill.

24361 and 24362. (No remarks.)

24363. Somewhat small, with dark skin.

24364. A large variety, about 5 inches by 4 inches; a splendid fruit.

24365 and 24366. MALUS spp.

From Jamaica Plain, Mass. Presented by Mr. Jackson Dawson, Arnold Arboretum. Received December 19, 1908.

Seeds of the following:

24365. MALUS SYLVESTRIS × BACCATA.

24366. MALUS BACCATA (L.) Moench.

"These are extraordinary keepers, and, as most of our crab apples are not good keepers, these therefore may be used in experimental work." (*Dawson*.)

To be used in breeding or as stocks in cooperative experiments with the Mississippi Valley Apple Breeders' Association.

24367. MEDICAGO SATIVA L.

Alfalfa.

From Arabia. Purchased from Mr. H. P. Chalk, manager for the Hills Brothers Company, in Bussorah, Persian Gulf, through Mr. William C. Magelssen, American consul, Bagdad, Turkey. Received December 5, 1908.

Arabian alfalfa or *Jet*. (See No. 12992 for description.) This has proved of great promise in Arizona and California.

24368. PANICUM SULCATUM Aubl.

From Miami, Fla. Received through Mr. P. J. Wester, in charge, Subtropical Garden, December 5, 1908.

24368—Continued.

"This plant does exceedingly well here, and it has recently occurred to me that it would be a successful and cheap substitute for palms for decorative purposes in the North." (*Wester.*)

"This is extensively grown in gardens in Mexico as an ornamental under the name of 'Hoja de vandra.'" (*Frederic Chisolm.*)

24369. VIGNA UNGUICULATA (L.) Walp.**Cowpea.**

From Biloxi, Miss. Procured by Prof. S. M. Tracy. Received November 25, 1908.

"A variety of cowpea, the vines of which were 50 feet long, and it was stated by the owner to grow 100 feet long. The plants were dead when I saw them, but the owner states that the plant is perennial. The pods are very large, measuring 10 inches in length and $\frac{1}{4}$ inch in width, while the seeds closely resemble those of the ordinary *Whippoorwill* variety." (*Tracy.*)

24370 to 24401.

From Russia. Received through Prof. N. E. Hansen, director, Agricultural Experiment Station, Brookings, S. Dak., December, 1908, while traveling as an agricultural explorer for this Department.

The following seeds and cuttings: -

24370. RIBES NIGRUM L.

24371. RIBES sp.

"(No. 5.) A wild black currant from near village Mali Ssusum, steamer landing place on the Obi River, a short distance north of Barnaul, Tomsk, western Siberia." (*Hansen.*)

24372. RIBES sp.

(Stat. Baljatakaija.)

24373. RIBES sp.

24374. RIBES sp.

"(No. 96.) A wild black currant from Taischet, between Krasnojarsk, central Siberia, and Irkutsk, on Lake Baikal, Siberian railway. For fruit breeding." (*Hansen.*)

24375. RUBUS sp.

"(No. 1.) A red wild raspberry as found native at Besentsug, near Samara, Volga River region, Russia. For fruit breeding." (*Hansen.*)

24376. RUBUS FRUTICOSUS L.

"(No. 6.) A wild raspberry gathered near Gorodische, on Obi River, a few miles north of Barnaul, Tomsk, western Siberia. Fruit much gathered by peasants and sold at steamer landings." (*Hansen.*)

24377. RUBUS FRUTICOSUS L.

"(Nos. 30 and 31.) A wild raspberry much gathered by peasants in western Siberia; this was procured at steamer landing Katschiskaya. For fruit breeding." (*Hansen.*)

24378. RUBUS sp.

"(No. 34.) Wild red raspberry from station Tiaschet, between Krasnojarsk, central Siberia, and Irkutsk, on Lake Baikal, Siberian railway. For fruit breeding." (*Hansen.*)

24370 to 24401—Continued.**24379. RUBUS CHAMEAMORUS L.**

"(No. 95.) A wild red raspberry from vicinity of Irkutsk, near western shore of Lake Baikal, eastern Siberia. May prove useful in plant breeding." (Hansen.)

24380. PRUNUS PADUS L.

"(No. 7.) A wild cherry gathered by peasants and sold at steamer landing at Gorodische, on Obi River, a few miles north of Barnaul, Tomsk, western Siberia." (Hansen.)

24381. PRUNUS PADUS L.

(Bada.)

24382. PRUNUS PADUS L.

(Bada.)

24383. PRUNUS PADUS L.

(Bada Baikal.)

24384. PRUNUS DOMESTICA L.**24385. ROSA sp.**

"(No. 19.) A wild rose as found between Ruchekowa and Koliwan, in northern Altai Mountain Range, southern Tomsk province, western Siberia." (Hansen.)

24386. ROSA sp.

"(No. 20.) A wild rose as found between Ruchekowa and Koliwan, in northern Altai Mountain Range, southern Tomsk province, western Siberia." (Hansen.)

24387. ROSA sp.

"(No. 47.) Wild rose from a sand desert, an arm of the Gobi desert, at station Charonte, Transbaikial region, a few miles over the Chinese border, on the Siberian railway." (Hansen.)

24388. ROSA sp.

"(No. 80.) A wild rose from the open steppe at Belaglasowa, southern Tomsk province, western Siberia." (Hansen.)

24389. MALUS sp.

"(No. 36.) From village Lisinsk, Semipalatinsk province, western Siberia. Probably a variety of the Siberian crab, *Pyrus (Malus) baccata*. See No. 44 (S. P. I. No. 24390)." (Hansen.)

24390. MALUS sp.

"(No. 44.) Same as No. 36 (S. P. I. No. 24389). Both from a lot sent to the experiment station, Omsk, Siberia." (Hansen.)

24391. PYRUS sp.

"(No. 45.) A small-fruited yellow pear sold by Chinese at fruit bazaar, station Manchuria, Siberian railway. Said to come from Harbin." (Hansen.)

24392. MALUS sp.

"(No. 48.) Seeds of a medium-sized subacid apple, yellow with red blush; sold by Chinese at fruit bazaar, station Manchuria, Siberian railway. Said to be shipped from Harbin district." (Hansen.)

24393. MALUS sp.

"(No. 49.) Same as No. 44 (S. P. I. No. 24390), but of a larger fruited variety." (Hansen.)

24370 to 24401—Continued.**24394.** *PYRUS* sp.**24395.** *CRATAEGUS* sp.**Hawthorn.**

"(No. 62.) Native hawthorn from Irkutsk, near Lake Baikal, eastern Siberia." (*Hansen.*)

24396. *VACINIUM* sp.

"(No. 46.) As gathered wild near Chita, Transbaikial region, and sold on fruit bazaar. The largest fruit of blueberry type I have ever seen, averaging three or four times larger than ordinary blueberries." (*Hansen.*)

24397. *FRAGARIA VESCA* L.

"(No. 2.) Seeds of a wild strawberry from near Syrastan, on the Siberian railway, western Siberia, between Zloutoust and Chelabinsk. For fruit breeding."

24398. *RUBUS* sp.

"(No. 97.) Wild raspberry from station Bogotol, between Taiga and Krasnoyarsk, central Siberia, on Siberian railway." (*Hansen.*)

24399. *FRAGARIA VESCA* L.

(St. Tajga.)

24400. *PAEONIA* sp.

"(No. 93.) As found wild near Stretinsk, near beginning of the Amur River, Transbaikial region, eastern Siberia. Here it gets extremely cold in winter. Of interest to breeders of *Pæonias*." (*Hansen.*)

24401. *CORYLUS* sp.

"(No. 70.) Probably *C. heterophylla*. The wild hazelnut from near Buchedu, in the Chingan Mountains, on the Siberian railway, in western Manchuria, the farthest eastern point reached in my 1908 trip." (*Hansen.*)

24402 and 24403.

From Piracicaba, Brazil. Presented by Dr. J. W. Hart. Received February 28, 1908. Numbered for convenience in distributing December, 1908.

The following plants:

24402. *PANICUM MUTICUM* Forsk.**Para grass.**

Apparently distinct from the ordinary variety of Para grass grown in the United States.

24403. *CAPRIOLA DACTYLON* (L.) Kuntze.**Bermuda grass.**

This grass is grown in Brazil under the name of "*Graminaz fina*." The variety is apparently distinct from the ordinary variety of Bermuda grass grown in the United States.

24404. COPERNICIA CERIFERA Mart. Carnauba palm or Brazilian wax palm.

From Piracicaba, Brazil. Presented by Dr. J. W. Hart. Received December 26, 1908.

"This tree is not native to this section of Brazil and it may be possible that these seeds will give you hardier plants than those grown in the hotter portions of the country." (*Hart.*)

"The stem of this plant furnishes starch; the sap, sugar; the leaves, a rope fiber; the pinnæ are woven into mats, hats, baskets, and brooms; the inner part of the leaf stalks serves as a substitute for cork, and most important of all the young leaves are

24404—Continued.

covered with a valuable wax harder than that of bees and used for making candles, covering phonograph cylinders, etc. Each tree furnishes about 4 pounds of wax annually." (*Adapted from Von Mueller.*)

24405 to 24413. EUCALYPTUS spp.

From Los Angeles, Cal. Purchased from Messrs. Johnson & Musser. Received December 21, 1908.

Seed of the following varieties to be tested in south Texas, Florida, and the Gulf Coast States on the recommendation of Messrs. Johnson & Musser:

- 24405.** *EUCALYPTUS CORNUTA* Labill.
- 24406.** *EUCALYPTUS CLADOCALYX* F. Muell.
- 24407.** *EUCALYPTUS LEUCOXYLON* F. Muell.
- 24408.** *EUCALYPTUS LONGIFOLIA* Link.
- 24409.** *EUCALYPTUS POLYANTHEMOS* Schauer.
- 24410.** *EUCALYPTUS LONGIROSTRIS* Muell.
- 24411.** *EUCALYPTUS RUDIS* Endl.
- 24412.** *EUCALYPTUS SIDEROPHLOIA* Benth.
- 24413.** *EUCALYPTUS VIMINALIS* Labill.

24415. EUCALYPTUS ALBA Reinw.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 4 and 21, 1908.

See No. 21394 for previous introduction and descriptive note.

24416. FRAGARIA sp.**Strawberry.**

From Shanghai, Kiangsue, China. Presented by Mr. J. M. W. Farnham. Received at the Plant Introduction Garden, Chico, Cal., December 16, 1908.

White.

24417 and 24418.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, at the Plant Introduction Garden, Chico, Cal., 1907; numbered for convenience in recording distribution December, 1908.

24417. CINNAMOMUM CAMPHORA (L.) Nees & Eberm. (?)

From Hangchow, Chekiang, China. "(No. 736a, June 27, 1907.) A very ornamental evergreen tree, bearing leaves like the camphor tree, but darker green and producing blue-black berries on red petioles. The Chinese chop the leaves up very fine, let them steep in water with clay or soil, and obtain a very good, weather-resisting cement in that way, especially used in plastering over old coffins which are kept standing above the ground." (*Meyer.*)

24418. SALIX BABYLONICA L.

From Fengtai, near Peking, Chihli, China. "(No. 665a, Mar. 26, 1907.) A weeping willow growing on very dry places; used as a shade tree in the streets of Peking under trying climatic and other conditions; well worth giving a trial in the western regions of the United States. Chinese name *Tsa yang liu.*" (*Meyer.*)

24419. GARCINIA sp.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 30, 1908.

Variety *pyriformis*.

24420. TRIFOLIUM SUBTERRANEUM L.

From Auckland, New Zealand. Presented by Mr. A. B. Leckenby, Central Hotel, through Mr. C. V. Piper. Received December 21, 1908.

"Abundant and useful in New Zealand." (*Leckenby*.)

24421. ANONA CHERIMOLA Mill.

From Calabria, Valley of Messina, Italy. Presented by Mr. C. Sprenger, Vomero, Naples, Italy. Received December 3, 1908.

Variety *Calabrica*.

24422 to 24428.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 28, 1908.

The following seeds:

24422. STIZOLOBIUM sp.

24426. MUCUNA sp.

24423. STIZOLOBIUM sp.

24427. MUCUNA sp.

24424. STIZOLOBIUM sp.

24428. MUCUNA sp.

24425. MUCUNA sp.

24429. CUCUMIS MELO L.**Muskmelon.**

From Odessa, Russia. Presented by Mr. Alfred W. Smith, American vice and deputy consul. Received December 28, 1908.

"This is a variety of sweet melon grown here and cultivated in several colors. It is known here as '*Kachanka*' and sometimes also called '*Tsesarka*,' on account of its spotted surface, resembling a guinea fowl's plumage." (*Smith*.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 154.

B. T. GALLOWAY, *Chief of Bureau.*

FARM WATER SUPPLIES OF MINNESOTA.

BY

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IN COOPERATION WITH

THE MINNESOTA STATE BOARD OF HEALTH.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 10, 1909.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 154 of the series of this Bureau a paper entitled "Farm Water Supplies of Minnesota."

This paper was prepared by Mr. Karl F. Kellerman, Physiologist in Charge of Water Purification Investigations, and Mr. H. A. Whittaker, Scientific Assistant, with the informal cooperation of the Minnesota State Board of Health. The successful prosecution of this work has been due to the laboratory facilities and assistance kindly placed at our disposal by Dr. H. M. Bracken, Secretary of the Minnesota State Board of Health, and his colleagues Dr. F. F. Wesbrook, Director, and Dr. H. W. Hill, Assistant Director of the laboratories of the State Board of Health, to the skillful and conscientious technical work of Dr. A. J. Chesley in bacteriology and of Mr. M. G. Roberts in chemistry, and to the keen interest and appreciation displayed at all times by the Board as the investigations progressed.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FARM WATER SUPPLIES OF MINNESOTA.

INTRODUCTION.

The chances of the dangerous pollution of a water supply increase as the surrounding or adjoining areas become more and more thickly settled, and, very naturally, the theories and methods of the sanitary control of water supplies have been developed in cities and from the standpoint of a congested population. It is becoming apparent, however, that even in this country, with its comparatively recent occupation and sparse rural settlement, both farm and city are suffering from the careless management of rural sanitation.

Two recent examples of this fact may serve more effectively to emphasize the moral that it is necessary to learn immediately whether dangerous sanitary conditions exist generally throughout the rural districts of the United States and to discover means of controlling or preventing such pollution. The first example is the prevalence of typhoid in the city of Washington, D. C., in spite of the fact that the water supply is filtered and of good character.^a The inference seems clear that this unfortunate condition is due to the presence of typhoid cases on the farms supplying dairy and other products.

The second example is the report of the very high percentage of typhoid fever cases in some of the rural districts of Maryland, reaching two and one-half times the percentage found in Baltimore, the largest city in that State.^b

While it is recognized that in only a limited percentage of cases can typhoid fever in rural districts be traced directly to the farm water, the condition of each supply fairly typifies the general conditions of

^a Rosenau, M. J., Lumsden, L. L., and Kastle, J. H. Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia. Public Health and Marine Hospital Service, Hygienic Laboratory, Bul. 35. 1907.

Horton, T. The Prevalence and Causation of Typhoid Fever in Washington, D. C. Engineering News, vol. 56, No. 19, pp. 484-488. 1906.

Sedgwick, W. T. Comments upon Mr. Horton's Report and upon the Typhoid Fever Situation in the District of Columbia. Engineering News, vol. 56, No. 19, pp. 488-489. 1906.

The Causes of Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 7, pp. 33-122. 1908.

Magruder, G. Lloyd. Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 6, No. 1, pp. 69-71. Mar., 1907.

^b Cited from Maryland Medical Journal by Dr. G. Lloyd Magruder. Washington Medical Annals, vol. 6, No. 1, March, 1907.

hygiene and sanitation upon the respective farms. Evidently, then, the study of farm supplies involves many problems in addition to the examination of the water actually in use. A complete sanitary survey of some representative area of considerable extent with a thorough investigation of all the factors bearing upon each and all of the supplies is necessary before intelligent recommendations for improvement can be made. Unfortunately such studies^a have not covered a sufficiently large area nor have a sufficient variety of methods been employed to meet these exacting requirements. Adequate knowledge of a single farm supply may require a study of the conditions of a rural home and its surroundings, and occasionally include the epidemiology of an entire neighborhood.

The scope of the investigations here presented is limited to a single State. This State, Minnesota, exhibits a wide range of rural conditions both from the economic point of view regarding mineral and agricultural resources and from the purely agronomic point of view regarding the variety of natural and cultural features incident to factors of climate, topography, geology, and relative age of settlement.

THE SELECTION OF SECTIONS FOR INVESTIGATION.

In the investigation of large sections of the country it is highly desirable to discriminate intelligently in the selection of the districts to be examined. The knowledge of the investigator preceding the investigation of a rural territory should include at least general information of the data available on its topography, geology, and hydrology.

The variation in these features makes possible the selection of certain typical sections which may fairly be compared with each other. It is, however, necessary at times to make examinations purely for epidemiological purposes even if this requires the duplication of certain lines of investigation.

The economic development of the territory is worthy of attention, and in interpreting data it must be kept constantly in mind, as it deals directly with the distribution of population, wealth, and resources.

^a The Water Supply. Oklahoma Agricultural Experiment Station, Bul. 66. 1905.
Miscellaneous Water Analyses. Oklahoma Agricultural Experiment Station, Bul. 67. 1905.

Palmer, A. W. Chemical Survey of the Water Supplies of Illinois. Report for the Years 1897-1902. University of Illinois. 1903.

Ladd, E. F. Waters of North Dakota. North Dakota Agricultural Experiment Station, Bul. 66. 1905.

Bartow, Edward. Chemical and Biological Survey of the Waters of Illinois. University of Illinois, Report for the Year Ending August 31, 1906, and Report, September 1, 1906, to December 31, 1907.

Dole, R. B., and Westbrook, F. F. The Quality of Surface Waters in Minnesota. U. S. Geological Survey Bul., Water-Supply and Irrigation Paper No. 193. 1907.

The distribution of these factors has a marked influence upon the sanitary condition of any community, as well as upon the feasibility of urging expenditures when improvements are desirable. This is especially noticeable in the field of epidemiology when the investigator is dealing directly with the source and transmission of a disease.

TYPES OF FARM WATER SUPPLIES WITH REFERENCE TO FACTORS OF POLLUTION.

Farm water supplies can be divided into two fairly distinct classes—underground and surface. The underground supplies consist of dug wells, bored wells, drilled wells, driven wells, and springs; the surface supplies consist of rivers, lakes, surface reservoirs, and cisterns. In Minnesota the supply in most general use is perhaps the dug well, although the ratio of the different types varies with the location. Springs are used to a limited extent, usually in cases where their location is convenient. The use of surface supplies ^a varies with the locality and depends mainly upon the availability or character of the underground supply.

The dug well, probably the oldest type of well known, is usually a round or square excavation several square feet in area, the depth varying in different localities according to the distance of the water-bearing stratum from the surface of the earth. Its construction varies widely in different localities. The crudest form of a dug well consists of a shallow hole in the ground which collects water both from the surface and from the upper layers of the soil and has no covering to serve as a protection. Water from such a well is usually dipped, either directly or by means of a rope and bucket. In such a well no attempt whatever is made to protect the water from pollution. In the development of the deeper dug wells necessity demanded the use of a casing to hold back the soil, and various materials have been used for this purpose. In pioneer settlements logs are sometimes used, while in many regions boards are found. Modern casings ^b include a number of materials, such as stone, brick, cement, concrete, and tile, installed in various ways. Casings are now meant to serve as a protection from surface pollution in addition to holding back the soil; therefore, not only the use of suitable material but also the proper installation of that material is of the utmost importance.

Certain methods of drawing water from a dug well afford avenues for pollution of surface origin. The old style of drawing water by means of a chain or rope and bucket is undoubtedly a dangerous one; most of the wells equipped in this way are entirely uncovered, permitting the entrance of various kinds of organic and inorganic matter,

^a Dole, R. B., and Westbrook, F. F., loc. cit.

^b For antiquity of wells and casings, see J. G. Swindell and G. R. Burnell, *Well-Sinking*, pp. 1-5. London, 1886.

and as the bucket on leaving the hands of the operator passes directly into the water an opportunity is given for polluting the well should the hands of the operator be infected. The ordinary type of iron pump is usually safe, although the so-called "priming" of pumps affords an opportunity for direct infection if the priming water or the vessel containing it is infected.

The covering of a dug well is also of great importance, and if tightly joined to the casing may prevent the entrance of surface pollution. Wood is used almost entirely for this purpose, but on account of the frequent wetting and drying to which most coverings are subjected, crevices soon form between the boards and foreign matter is admitted with the waste water from the pump. The covering of a well should be kept as dry as possible, and the surface immediately surrounding a well should slope away in all directions, in order to form a protection from surface water.

The bored well is used to a limited extent in various localities and is dug with machines made for that purpose. It differs from the dug well principally in size, the total area of the ordinary bored well being about one square foot. The casing used for this type of well is made of wood, tile, or tin. The tin casing used in certain sections is simply a soldered tin pipe extending the entire depth of the well. Long slender buckets with loose bottoms are used for drawing the water where the method of drawing is confined to the rope and bucket. The bored well is subject to practically the same criticisms of construction as the dug well. The area of surface exposed to external polluting influences is much smaller, yet it should be protected in the same careful manner recommended in the case of the dug well.

The drilled well, as the name signifies, is installed by means of a drilling apparatus. This type is usually found in sections where water is obtained only at a considerable depth and where the penetration of rock or some other hard stratum is necessary. The size of the shaft varies from about two inches to several feet.^a The casing in some wells extends to the bottom and in others only to the rock formation, beyond which point the rock itself serves this purpose; the casing usually meets the base of the pump above the surface of the ground.

If a well pit has been excavated the casing extends only into that. In any case it should be tightly covered in order to prevent the entrance of surface pollution. Drilled wells very frequently have well pits which are about the size of a dug well and are from 8 to 12 feet in depth. Well pits 8 to 12 feet in depth and 3 to 4 feet in diameter are often sunk around the shaft for the purpose of protecting parts of the pumping apparatus from frost, and at times are a prominent factor in the pollution of a well, serving as catch basins

^a Vernon-Harcourt, L. F. Sanitary Engineering, pp. 62-78. London, 1907.

for polluted water of recent surface origin. The depth of some wells is increased by driving or drilling. In these cases the dug portion really serves as a well pit and should be carefully protected against pollution.

The driven well, a type of supply first used at the beginning of the nineteenth century,^a is usually found in localities where water is secured relatively near the surface. The casing consists of sections of iron pipe screwed into couplings so as to be continuous and water-tight throughout. The lower end of the pipe is armed with a sharp metallic point perforated with holes, which serves as a penetrating instrument during driving, and prevents the soil from entering the pipe. The iron pipe used for casing is usually about 2 inches in diameter, but varies in size from 1½ to 10 inches.^b Well pits are even more common with the driven than with the drilled well. In the driven well the shaft is usually not large enough to inclose the part of the pump which requires protection from frost, and a well pit is practically necessary with the ordinary type of iron pump. The driven well requires less care and is probably as safe as any type of moderately shallow supply.^c

Springs are used to a limited extent as a source of farm water supply, their use depending mainly upon their convenience. A spring often may be made a safe supply by carefully protecting it against surface pollution, although in general the same factors influencing the safety of dug wells should receive consideration.

Cisterns are a very common form of farm water supply in certain localities where the underground water is hard to obtain or is unfit for use; historically they are perhaps the oldest form of artificial supply.^d They are used for the storage of water from various sources, but usually for rain water. They may be constructed of brick and mortar, concrete, stone, etc., usually underground, or of galvanized iron, and placed wherever convenient. If well located and protected, the latter type should be satisfactory. The temptation is great, however, to locate this type on the surface, and in this case the temperature of the cistern water during the summer season is much higher than that in the underground type, and the growth of

^a Olshausen, J. Schlagbrunnen. Gesundheits Ingenieur, 23. Jahrg., No. 17, pp. 278-280. 1900.

Sinking Driven Wells. Engineering Record, vol. 40, pp. 362-363. 1899.

Noyes, A. F. The Driven-Well System as a Source of or a Means of Obtaining a Water Supply. The Sanitary Engineer and Construction Record, vol. 16, pp. 264-265. 1887.

^b Sinking Driven Wells. Engineering Record, vol. 40, pp. 362-363. 1899. See also Vernon-Harcourt, loc. cit., p. 48.

^c Sutcliff, R. "Abyssinian" Tube Wells. Cited from Journal of Society of Arts by Van Nostrand's Engineering Magazine, vol. 23, pp. 281-285. 1880.

^d Larousse, P. Citerne. Grand Dictionnaire Universel, vol. 4.

organisms, which are usually present in waters collected from roofs, is encouraged rather than discouraged. A roof which is the catchment area for cistern water may also collect anything carried in the air. The character of the materials deposited will of course depend upon the section of the country and the season of the year. Some of the most common are dust, dead insects, excreta from fowls of the air, seeds and spores of plants, and even vegetable growths. Sometimes a roof is constructed of material which can be partially extracted by rain water, and the solution thus formed becomes very objectionable at times, especially if the water collected is to be used for drinking purposes.

After the water enters the cistern proper the opportunities for pollution depend mainly upon the construction and protection of the type of cistern in use. Leaks probably offer one of the greatest opportunities for pollution if the cisterns are located beneath the surface; in this case ground water is often given free entrance. Ground water in the neighborhood of cisterns is not infrequently polluted, for in its passage through the small amount of surface soil usually covering a cistern very little purification is effected. Priming is usually necessary in cistern pumps, and when water-borne diseases are present in the home this practice may prove a very dangerous factor in the transmission of disease. The quality of cistern water can be much improved by installing a device for turning away the water caught during the first part of a shower; this secures a thorough washing of the roof before any water enters the cistern.

Surface reservoirs are built in certain farming sections^a for collecting and holding surface water. The construction of the ordinary type is very simple. A portion of the surface soil is removed, which leaves a depression for collecting water from a small natural or artificial catchment area. These reservoirs are usually located in a more or less impervious soil, although clay is sometimes used to line a reservoir which would not otherwise hold water. Water for domestic purposes is either dipped or pumped from these reservoirs. When pumps are used they are suspended on a platform built over the water which is connected with the shore by a board walk. The purity of such a supply depends mainly upon the protection of the area from which the supply is collected; the season will also influence the condition of the water, depending upon the temperature, rain, snow, wind, and other atmospheric conditions.

Rivers and lakes are used to a very limited extent as a source of drinking water for farms in Minnesota. Their potability depends almost entirely upon the environment of the individual lake or river in question. The pollution includes principally waste material contributed by thickly populated communities. In rural communities

^a In Kittson County, Minn., this practice is common.

rivers and lakes are used more extensively during the winter season, the temperature at that time making the water more palatable, although probably no less dangerous.

METHODS OF COLLECTION AND EXAMINATION OF WATER SUPPLIES.

The selection of farms for illustrating various conditions of rural sanitation is best made by actual observation and from information secured in the field. If possible, several types of water supplies are chosen in each community, though these selections are of course influenced by the sanitary environment of the different types, more time being given to the investigation of unsatisfactory conditions. The data secured in the present investigation and recorded in the field are grouped under three general headings: (1) Identification data; (2) general and structural water data; and (3) general sanitary and epidemiological data. The laboratory determinations are reported in Table IV, pages 78 and 79.

The identification data for various reasons have been sufficiently abridged so that only the general location of the farms under discussion can be determined.

The general sanitary and epidemiological data may be of direct or indirect interest in reference to the water supply, but in either case include a concise statement of the apparent character of the supply. This statement may or may not uphold the results of the analysis of the samples of water collected, but is essential for interpreting correctly the chemical and bacteriological data.

The collection of field data and samples of water was made by Mr. H. A. Whittaker, representative of the Bureau of Plant Industry. Both chemical and bacteriological samples were taken from each supply investigated and were shipped immediately to the laboratories of the Minnesota State Board of Health for examination. The chemical and physical analyses were made partly by Mr. M. G. Roberts, of the State Board of Health, and partly by Mr. Whittaker, in accordance with the recommendations of the committee on standard methods of water analysis of the American Public Health Association. The bacteriological counts and the tests for *Bacillus coli* were made by Dr. A. J. Chesley, of the State Board of Health laboratories. The method used in examination followed the recommendations of the committee mentioned, with the following exceptions:

(1) Agar was used instead of gelatin for counts.

(2) Incubation was at room temperature and for four days from time of plating. If less than four days were established as a limit, plates would often be received in the laboratory so long after plating that the allowed incubation period would already have been exhausted in transit.

(3) The colon tests recommended alternatively as procedure A and procedure B by the committee on standard methods of water analysis of the American Public Health Association were both employed, the former on 100 c. c. samples enriched by quadruple strength broth and incubated; the latter on 1 c. c. samples prepared in the field, which is also an enrichment method.^a

(4) The preparation of media followed strictly the committee's recommendations except in the following details:

Plain nutrient broth. Sterilized in an autoclave.

Dextrose broth. The muscle sugar removed.

Milk. Owing to variability of ordinary milk the following substitute was used: Nutrose (sodium-phosphate-casein) 2.6 grams, lactose 1 gram, distilled water 100 c. c. Heat to dissolve casein, but *do not boil*; filter, tube, and autoclave fifteen minutes at 15 pounds.

Potato. Not prescribed by the committee. This is prepared by cutting diagonal half cylinders from good fresh potatoes and washing over night to remove acidity. The half cylinders were dropped large end down into test tubes containing wet cotton at the bottom. The potato tubes were autoclaved.

The order of procedure in the adjustment of acidity in nutrient agar and gelatin media was slightly changed.^b

(5) From all the dilutions made those plates were selected which yielded counts of not much above 200, all that were higher or lower being disregarded. If deep well waters or other waters normally showed counts below 40 to each cubic centimeter, several plates were made and the results averaged.

The traveling laboratory case designed by Dr. H. W. Hill, Assistant Director of the Minnesota State Board of Health Laboratories, as an improvement on the field outfit formerly in use for sanitary studies of water supplies, is very complete and satisfactory for work of this character, and at our request Doctor Hill has furnished the following description:

The traveling laboratory case is a box made of half-inch pine, 18½ inches long, 6½ inches wide, and 16½ inches high, outside dimensions. The front opens on strap hinges at the base. The top is supplied with a comfortable handle and opens on strap hinges at the back; it carries a hinged iron strap, which engages with a staple on the front and is secured with a padlock. The box is treated inside and out with anilin black, and the corners are protected by trunk shoulder plates.

A half-inch horizontal partition divides the box into two sets of compartments. The lower set consists of three compartments 8 inches high and 6 inches deep; two of these, adjoining, are 5 inches wide; the third is 6½ inches wide. The 5-inch compartments each carry ten Petri dishes, which are wrapped in filter paper before sterilization to exclude dust and to prevent breakage in transit. The third compartment carries a Barthel alcohol lamp, and inverted over the lamp is a copper dish (4 inches in diameter, 5 inches high), for boiling water to melt agar media, and a tripod for supporting the dish on the stem of the lamp. A small bottle for extra alcohol and one or two towels also fit into this compartment. The upper set consists of one large compartment 6 inches deep, 7 inches high, and 10½ inches wide, and a small one 6 inches

^a Wesbrook, F. F. Laboratory Methods and Devices. Journal of Infectious Diseases, Supplement No. 1, pp. 322-323. 1905.

^b Hill, H. W. Suggestions for Changes in the Schedules for Making Broth, Gelatin, and Agar, etc. Journal of Infectious Diseases, Supplement No. 2, pp. 223-225. Feb., 1906.

deep, 7 inches high, and $6\frac{1}{2}$ inches wide. The small compartment carries six cylindrical 4-ounce glass-stoppered collecting bottles and two rectangular 5-ounce rubber-stoppered bottles for sterile dilution water. The large compartment contains two wooden test-tube racks, supported by vertical guides at the ends, and constructed of $\frac{1}{4}$ -inch pine as follows: From the center line of a flat wooden base ($1\frac{1}{2}$ inches wide and 10 inches long) rises a flat sheet of wood (5 inches high and $10\frac{1}{2}$ inches long); narrow vertical strips of wood at each end of each side of this sheet coapt with the vertical guides on the ends of the compartment, leaving a narrow edge of the ends of the sheet exposed to slide in the slots of the guides. Two pins in each vertical strip permit rubber bands to be stretched across each side of each sheet from end to end. The test tubes are inserted between the sheet and the rubber bands on each side of the sheet, resting on the wooden base. Each rack carries about twenty test tubes. The floor of this compartment next to the back of the box is cut away along its whole length for a width of $1\frac{1}{2}$ inches; through this opening pass pipette cases containing two thermometers and about twenty pipettes, four pipettes to a case. Between the racks is space for an envelope containing gummed labels, spare elastics, a lead pencil, a glass pencil, etc., and cards for recording data on samples collected.

APPARATUS.

Petri dishes.—Twenty to twenty-two standard 4-inch dishes with porous tops.

Test tubes.—Forty to forty-five standard 6-inch by $\frac{1}{4}$ -inch tubes; twenty to twenty-two containing 10 c. c. each of standard agar for plating, the remainder plugged and sterilized but empty, for making dilutions, etc.

Pipettes.—Six cases of four 1 c. c. pipettes each; one case containing 5 c. c. pipettes.

DESCRIPTION OF THE WATER SUPPLIES EXAMINED.

In the course of the present investigation 28 dug wells, 6 bored wells, 13 drilled wells, 19 driven wells, 2 springs, 1 river,^a 2 surface reservoirs, and 5 cisterns were examined. A brief statement of the sanitary condition of each supply is made, based partly upon the data secured from the chemical and bacteriological studies of water samples and partly upon the conditions shown by the sanitary inspection of the environment of the various supplies.

The identification of supplies as either good or polluted can be made only by laboratory investigations upon properly collected fresh samples of the water, together with a personal inspection by a trained expert of the environment of the supply.

Further explanation is perhaps desirable regarding the use of the terms "good" and "polluted" in the following descriptions of the various water supplies. A water supply to be described as good must be so located that the apparent possibilities of dangerous pollution are remote, and the samples of water taken for laboratory study must conform to the definition ^b of a pure and wholesome water:

Unquestionably the term "pure and wholesome water" as ordinarily used relates to water intended to be used for drinking. Such a water must be free from all poisonous substances, as the salts of lead; it must be free from bacteria or other organisms

^a The Red Lake River, on which four of the supplies examined were located.

^b Whipple, George C. *The Value of Pure Water*, pp. 3-4. New York, 1907.

liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as *B. coli*. In other words, the water must be free from poisonous substances, from infection, and even from contamination. By this term is meant pollution with fecal matter. Contamination must be considered as potential infection. Besides this, it must be practically clear, colorless, odorless, and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension. Moreover, it must be well aerated. Color, turbidity, odor, dissolved salts, etc., may be permissible to a small degree without throwing the water outside of the definition of pure and wholesome waters. In these minor matters local standards govern up to a certain point, and it is in regard to them that differences in judgment and experience of analysts lead to diverse classifications.

Dug well No. 7 illustrates these conditions. The environment of the well appears reasonably safe even though it is not entirely satisfactory, and the analytical data secured from the water samples indicate a good water both chemically and bacteriologically. Dug well No. 10 shows the opposite conditions; the environment is very unsatisfactory, and the laboratory studies show that the water is polluted.

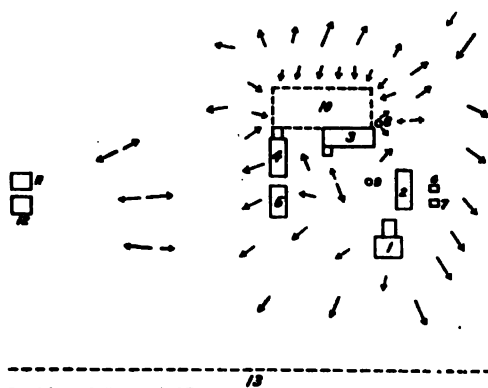


FIG. 1.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 1: 1, Farmhouse; 2, stone house; 3, hay barn with basement; 4, chicken house; 5, granary; 6, storehouse; 7, privy; 8, dug well; 9, drilled well; 10, barnyard; 11, hay barn; 12, hay barn; 13, public road.

tion of the farms, for obvious reasons, is shown only in an approximate way. Arrows are used in the accompanying sketches to show the slope of the ground.

DUG WELLS.

No. 1. A polluted supply. The dug well should be abandoned and water taken from the drilled well.

Location of farm.—Merriam Park, Minn.

Date of visit.—July 3, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—In general, slope of ground is away from house and from most of the outbuildings. The barnyard slopes in the direction of the basement stable.

Source of water supply.—(See fig. 1.) The well in use is adjacent to the stable and barnyard; 28 feet in depth; casing, brick. The unused well, which is of the drilled type, is located midway between the house and stable, 140 feet deep, with a 3-inch iron casing well protected at surface. *Strata:* Dug well (No. 8), 23 feet surface clay and 5 feet sand; drilled well (No. 9), 130 feet surface clay and hardpan, 5 feet

rock, and 5 feet gravel. *Yield:* Dug well, abundant during wet season; drilled well, abundant at all seasons. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Dug well (No. 8) is only 15 feet from barnyard; however, surface of well is raised about 5 feet above level of yard. The barnyard unfortunately has no drain, and the surface of the yard is covered with a saturated mixture of water and manure most of the year. The danger to the shallow well is increased from the fact that the supply at times is scarcely adequate. The possibilities of polluting the drilled well (No. 9) from its surroundings are limited on account of its depth and surface protection. This well would undoubtedly make the safest supply, but as more effort is required to pump the water from a depth of 140 feet and because of the added objection of a slight iron taste, it has been almost entirely abandoned; it is now used only in case the supply in the dug well is insufficient.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Used on farm. Sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A polluted supply. It would be impracticable to attempt to obtain a potable supply from this well.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-six acres.

Kind of farming.—Dairy.

Topography.—The well is in the center of a marshy field about 20 rods from the house and barn. The barn is on dry land elevated several feet above the marsh. The slope from the house to the well is very gradual.

Source of water supply.—(See fig. 2.) The well is in the center of a marshy field surrounded by ponds; 15 feet in depth; casing, wood. *Strata:* Soft marsh soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* The well is probably in the poorest location possible to select, and its mouth has little protection from surface washings. Cattle make the well a resting place and considerable manure is deposited about the well ready to be carried in by surface washings.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds adjacent to well. The surface of these ponds is partly covered with a green growth, the odor from which would indicate very stagnant water. Some of the water in these ponds undoubtedly finds its way into the well.

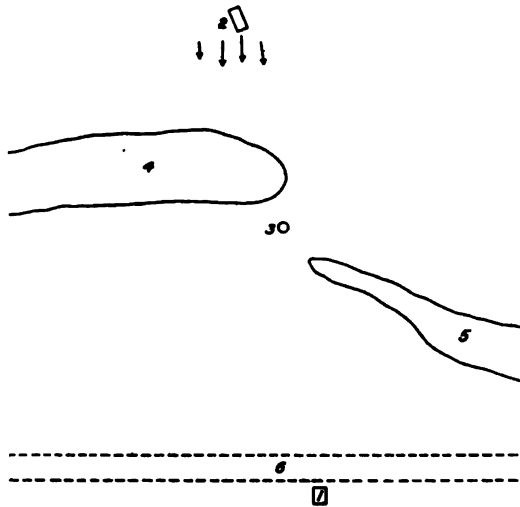


FIG. 2.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 2: 1, House; 2, barn and stables; 3, well; 4, pond; 5, pond; 6, street.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; manure is thrown out on two sides of the stable and the leachings flow back under the stable floor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A slightly polluted supply. This pollution could be avoided by installing a good casing and a tight covering.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—Twelve acres; 2 owned and 10 rented.

Kind of farming.—Dairy.

Topography.—The house is located on the highest ground, the elevation being about 5 feet above the well and outbuildings.

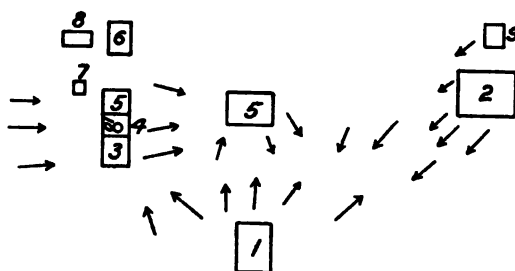


FIG. 3.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 3: 1, House; 2, stables; 3, wagon shed; 4, pump house; 5, tool shed; 6, ice house; 7, privy; 8, hogpen; 9, chicken house; 10, well.

Source of water supply.—(See fig. 3.) The well is in a protecting shed; 80 feet in depth; casing, 1½-inch planks; area of well, 3 square feet. *Strata:* Unknown. *Yield:* Abundant. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Poor. The casing near the surface is loose and affords opportunity for entrance of surface water. The well cover appeared very unclean, as the pump house had been used for sheltering chickens.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables fair; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—The owner of the farm had a severe case of typhoid two years previous to the date of visit. He was accustomed to visit the city of St. Paul daily. The entire family drank this well water at the time, but no others became infected. It would seem reasonable to suppose that the fever was contracted elsewhere than on the farm.

Analyses.—See page 78.

No. 4. A polluted supply. This supply could be very much improved by the installation of proper casing, covering, and pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—The general slope of the ground is away from the house in the direction of the stables. The house is 3 feet above the mouth of the well and about 8 feet above the outbuildings, and a pond is on a still higher elevation.

Source of water supply.—(See fig. 4.) The well is about 20 feet from the house and 30 feet from a marshy pond; 38 feet in depth, 3 feet square; casing, 1½-inch wood planks. **Strata:** Clay, 28 feet, and sandy gravel, 10 feet. **Yield:** Abundant in summer, but scanty during the winter. This would seem to indicate that the well was drawing from the pond, as this source of supply would be cut off during the winter. **Use:** Drinking and general farm purposes. **Method of lifting:** Old-fashioned bucket, pulley, and rope. **Sanitary aspect:** The well is dangerously located. The house is only 21 feet away and on a higher level; a stagnant marshy pond is within 30 feet on a higher level; the unprotected privy vault is on the same level and within 35 feet. The mouth of the well is protected only with the usual slant-roof covering of bucket wells. At high-water periods the pond overflows and forms a stream not 15 feet from the well. The casing does not extend above the surface of the ground.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A marshy pond filled with stagnant water during the entire year.

Sanitary condition of farmhouse and outbuildings.—Very poor in every way.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. A slightly polluted supply. The character of the water could undoubtedly be improved by better surface protection.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—The ground slopes away from the house in all directions. The house is 3 feet above the barn and 14 feet above the well. The slope from north to south is quite gradual at first and then becomes very abrupt.

Source of water supply.—(See fig. 5.) The well is 200 feet from the stables and approximately 400 feet from the house. It was originally an ordinary dug well, but later a 12-inch tile casing was placed down the entire depth of the well and stones of various size filled around it. The well is 25 feet deep. **Strata:** Clay entire depth. **Yield:** Abundant. **Use:** Drinking and general farm purposes. **Method of lifting:** Ordinary wooden pump with wooden pipe extending to the bottom of the well. **Sanitary aspect:** Fair. The tile casing extends above the surface, but does not exclude the danger of seepage through the loose stone filling surrounding the tile. **Abandoned well:** A well (No. 9) 160 feet deep was abandoned some years ago on account of a bad odor, excessive iron, and extreme hardness of the water.

Cisterns: One, used for drinking and washing purposes; contains a filter wall and appears to be in good condition.

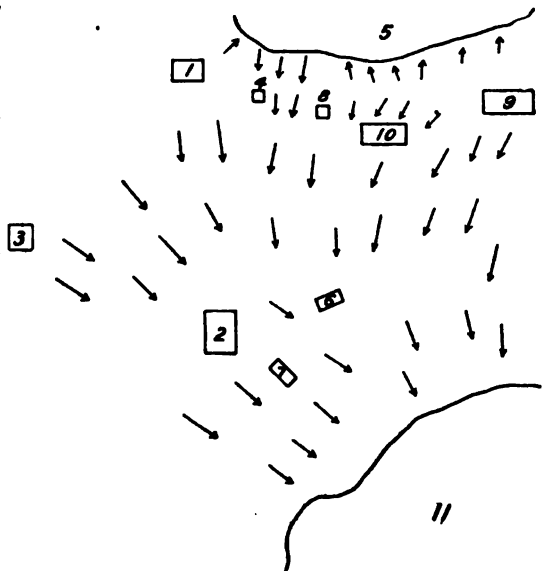


FIG. 4.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 4: 1, House; 2, stables; 3, granary; 4, well; 5, pond; 6, chicken house; 7, chicken house; 8, privy; 9, hogpen; 10, cow stable; 11, pond.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House in exceptionally good condition; stables well cared for; privy poor; unprotected vault.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—No record of any having occurred in recent years.

Analyses.—See page 78.

No. 6. Probably a polluted water, although the bacteriological data are lacking. This supply could undoubtedly be made safe by installing a pump, extending the casing above the surface, and banking and trenching to protect from surface pollution.

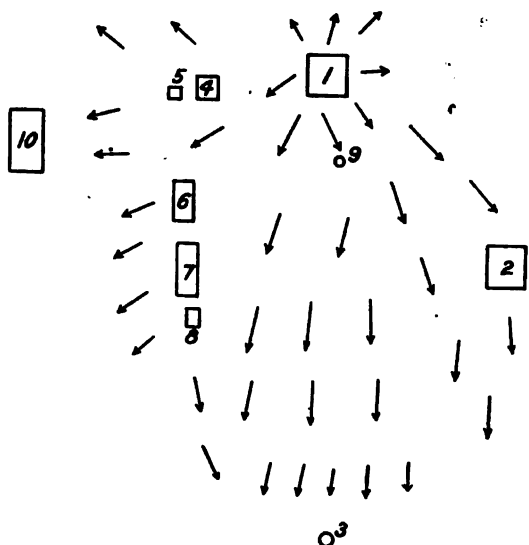


FIG. 5.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 5: 1, House; 2, barn; 3, well; 4, ice house; 5, privy; 6, wagon shed; 7, granary; 8, chicken coop; 9, abandoned well; 10, hay barn.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One small lake; also a creek leading into lake.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, unprotected vault.

Milk.—None.

Water-borne diseases.—One case of typhoid thirteen years ago, at which time a different water supply was used.

Analyses.—See page 78.

No. 7. A good water. The mouth of the well should be protected from surface wash, and a good casing and covering should be installed. In its present condition the supply is in danger of pollution.

Location of farm.—Gladstone, Minn.

Date of visit.—July 18, 1908.

Size.—Seventy-five acres.

Kind of farming.—Dairy.

Topography.—The slope of the ground is away from the house in all directions. The well is 3 feet lower than the house, and the stables are about 5 feet lower than the well.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Thirteen acres.

Kind of farming.—General.

Topography.—The slope of the ground is generally in one direction; the total fall between privy and stable, a distance of about 150 feet, is about 10 feet.

Source of water supply.—(See fig. 6.) The well is midway between the house and the stables; 22 feet deep, wooden casing. *Strata:* Clay, 9 feet, and sand, 13 feet. *Yield.*—Abundant. *Use:* Drinking and general farm purposes. *Method of lifting.*—Rope and bucket. *Sanitary aspect:* Bad; no protection whatever has been provided against surface wash and the well seems to be in bad condition.

Source of water supply.—(See fig. 7.) The well is covered by the pump house; 20 feet in depth; casing, ordinary 1½-inch planks. *Strata:* Gravel and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Ordinary iron pump; windmill used for power. *Sanitary aspect:* Fair. The location is slightly below that of the surrounding ground and the mouth of the well has no protection from surface wash. Slop from the milk house is thrown on the ground near the well and undoubtedly finds its way into the well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several small ponds; one small marshy pond about 20 rods back of house.

Sanitary condition of farmhouse and outbuildings.—House good; milk house fair; stables poor; privy poor, unprotected vault.

Milk.—Retailled in St. Paul; sanitary care fair.

Water-borne diseases.—No record of any for the past three years.

Analyses.—See page 78.

No. 8. A polluted supply. It is possible that this supply could be protected from pollution if a tight casing was installed; however, owing to the dangerous location and shallow depth of the well this is doubtful.

Location of farm.—Hastings, Minn.

Date of visit.—July 22, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

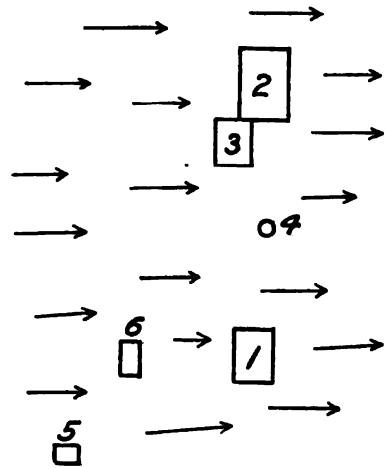


FIG. 6.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 6: 1, House; 2, barn and stables; 3, wagon shed; 4, well; 5, privy; 6, woodshed.

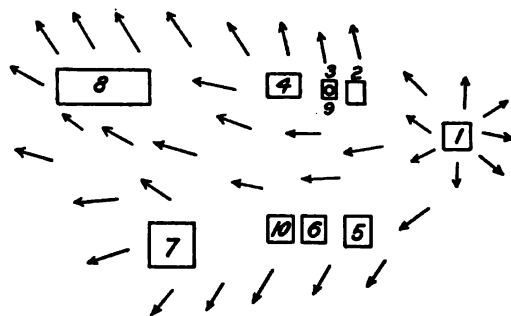


FIG. 7.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 7: 1, House; 2, milk house; 3, pump house; 4, wagon shed; 5, tool shed; 6, ice house; 7, horse barn; 8, cow stable; 9, well; 10, wagon shed.

Topography.—The surface slopes from the house in the direction of the well and outbuildings.

Source of water supply.—(See fig. 8.) The well is about 15 feet from the barnyard on low ground; 18 feet deep; casing, uncemented stone. *Strata:* Gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; well too near the barnyard. The surface is well protected with tightly matched heavy planks. The

mouth of the well is raised about 6 inches above the cement floor of the pump house.

Cisterns.—Used for washing only.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Exceptionally good.

Milk.—Skimmed milk used on farm; cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 9. The cistern supply is polluted. The well is satisfactory and should be used for direct supply where water of good sanitary quality is needed.

Location of farm.—Hastings, Minn.

Date of visit. July 22, 1908.

Size.—Forty acres.

Kind of farming.—Dairy and general.

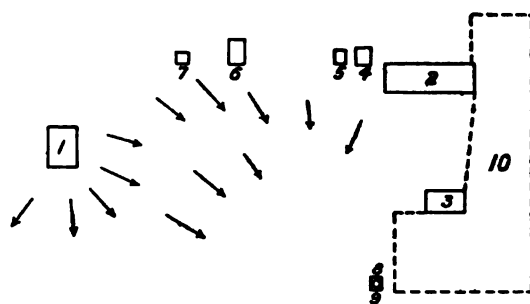


FIG. 8.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 8: 1, House; 2, stables; 3, stone house; 4, granary; 5, corner; 6, ice house; 7, privy; 8, pump and milk house; 9, well; 10, barnyard.

Topography.—The house is about 35 feet from the well and about 3 feet higher; the general slope is in the direction of the outbuildings.

Source of water supply.—(See fig. 9.) The well is 35 feet from the house and 20 feet from the stables; after digging the well a 6-inch tile casing was installed and the well filled; 127 feet in depth.

Strata: Mixture of sand and gravel. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of*

lifting: Iron pump; windmill used for power. *Sanitary aspect:* Well fair; cistern poor. *Cisterns.*—Well cistern located at corner of stable about 15 feet from the well; circular, with flat bottom and arched top, cement bottom, sides, and top; capacity, 75 barrels. The water is pumped from the well into the cistern as a reserve supply in case the windmill fails to pump. Almost the entire supply, drinking included, is used from this cistern. An ordinary iron hand pump is used to draw water.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Retailled in city; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 10. A polluted supply. The well should be condemned for domestic use and another sunk in a more suitable place.

Location of farm.—Red Wing, Minn.

Date of visit.—July 23, 1908.

Size.—One hundred and three and one-half acres.

Kind of farming.—Dairy.

Topography.—The entire drainage from all the buildings and the barnyard reaches the well, which is about 12 feet below the highest point of the yard.

Source of water supply.—(See fig. 10.) Well at corner of barnyard; 15 feet in depth; casing, uncemented stone. *Strata:* Ordinary black marshy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, though on date of visit the pump was out of order and the water was drawn with a rope and

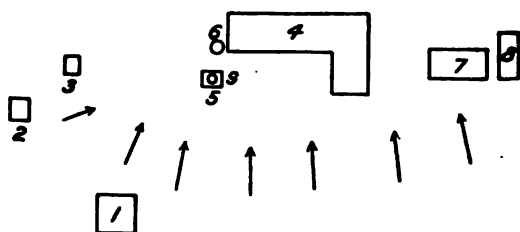


FIG. 9.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 9: 1, House; 2, ice house; 3, privy; 4, stables; 5, milk and pump house; 6, cistern well; 7, chicken coop; 8, hogpen; 9, well.

tin pail. *Sanitary aspect:* Bad; surface wash from the entire barnyard and stables has ample opportunity for reaching the well in case of heavy rain. The unprotected privy vault is located above the well. The ground surrounding the well is marshy and is flooded during the spring season of the year.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Many springs in the marshy section on which the well is located. Hay Creek, a small stream, flows through the marsh 10 to 15 rods from the well.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 11. A polluted supply. This well might furnish a good supply if great care was taken in protecting it from both surface and underground pollution by installing a proper casing and a tight covering.

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Three acres.

Kind of farming.—General.

Topography.—Level of well about 1 foot below that of house.

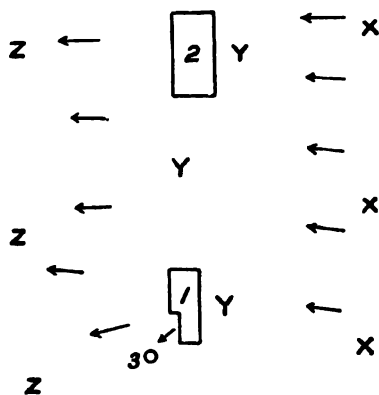


FIG. 11.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 11: 1, House; 2, barn; 3, well. X, High ground; Y, intermediate; Z, low ground.

ply could be made a safe one.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—Dairy and general.

Topography.—Low level ground in the Minnesota River Valley.

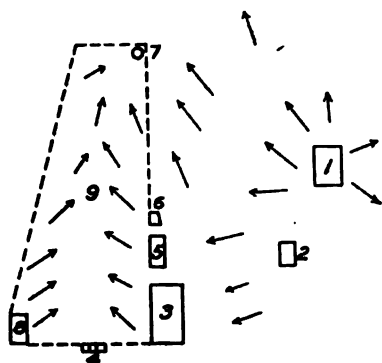


FIG. 10.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 10: 1, House; 2, wood shed; 3, barn and stables; 4, bridge; 5, milk house and corner; 6, privy; 7, well; 8, hogpen; 9, barnyard.

Source of water supply.—(See fig. 11.) Well about 30 feet from the house; 10 feet in depth; no casing. *Strata:* Surface soil and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The mouth of the well is practically unprotected and can receive polluted surface drainage.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables good; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 12. A polluted supply. It is very doubtful whether this sup-

Source of water supply.—(See fig. 12.) Well at the side of the house porch; 25 feet in depth; casing, uncemented stone. **Strata:** Sand, clay, and gravel, more or less mixed. **Yield:** Abundant. **Use:** Drinking and house purposes. **Method of lifting:** Iron pump. **Sanitary aspect:** Bad; polluted from upper strata and also from surface wash. About July 1 the house cellar filled with surface water and the well water could not be used on account of its disagreeable taste and odor. Covering of well in

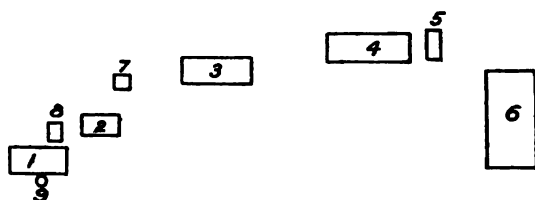


FIG. 12.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 12: 1, House; 2, ice house; 3, tool shed; 4, tool shed; 5, chicken house; 6, barn and basement; 7, privy; 8, milk house; 9, well.

good condition but on a level with surrounding ground.

Cisterns.—One, used for washing only.

Lakes, rivers, ponds, and springs.—Ponds during wet season. One spring, used for watering cattle.

Sanitary condition of farmhouse and outbuildings.—

House very good; stables

very good; milk house good; privy poor, open vault and unprotected.

Milk.—Retailed in city; sanitary care good.

Water-borne diseases.—One case of typhoid. A boy, aged 15 years, taken ill July 18; doctor called July 19 and pronounced the case typhoid; temperature 101°. This boy drank water in Mankato on July 5 and 12, which was during the course of a severe typhoid epidemic. From the dates of other cases in Mankato and from the fact that the trouble in that city is laid to the city water, which the boy drank, it is reasonable to assume this as the source of infection.

Analyses.—See page 78.

No. 13. A polluted supply. By proper grading and draining and by installing a good casing and tight covering this supply could be made safe.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—Twenty-eight acres.

Kind of farming.—Dairy.

Topography.—The surface surrounding the house and outbuildings is generally level, although several slight depressions hold surface water during the wet season.

Source of water supply.—(See fig. 13.) Well about 25 feet from house; 12 feet in depth; casing, uncemented stone. **Strata:** Blue clay, 8 feet, and gravel, 4 feet. **Yield:** During dry season supply is uncertain. **Use:** Drinking and general farm purposes. **Method of lifting:** Iron pump. **Sanitary aspect:** Bad. Well receives surface wash from entire house and barnyard. Covering poor and allows back flow of water from pump. Privy, with old open vault, 25 feet from well. Pond polluted with algæ is located some 25 feet from the well and at about the same level.

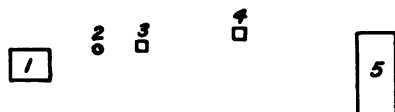


FIG. 13.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 13: 1, House; 2, well; 3, tool shed; 4, privy; 5, barn and stable.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds during wet season.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 14. A good supply, although it may become polluted by drainage from the upper strata.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—Sixty-five acres.

Kind of farming.—Dairy.

Topography.—House and outbuildings on level ground.

Source of water supply.—(See fig. 14.) Well about midway between house and stables; 27 feet in depth; casing, uncemented stone. *Strata:* Surface soil and blue clay.

Yield: Abundant except during a very dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good, although well is too near barnyard. Mouth of well slightly raised and well covered.

Cisterns.—One, used only for washing.

Lakes, rivers, ponds, and springs.—Ponds during wet seasons.

Sanitary condition of farmhouse and outbuildings.—

House good; stables good; milk house good; privy fair.

Milk.—Retailed in city of Mankato; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 15. The house supply is polluted, a condition which could be remedied by installing a good casing and a tight covering.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—Two hundred acres.

Kind of farming.—Dairy and general.

Topography.—House and barn about 2 feet higher than intervening land.

Source of water supply.—(See fig. 15.) House supply (No. 2) under house porch; 40 feet in depth; casing, stone. *Strata:* Blue clay. *Yield:* Abundant.

Use: Drinking and house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Poor. The well receives surface wash at times of excessive rain. The open-vault privy is located some 40 feet away, which makes the location of the well more unsuitable. *Stable supply* (No. 9) near stables; 40 feet in depth; casing, wood. *Strata:* Sand, 15½ feet, and blue clay, 24½ feet. In this case a vein of water was found in the blue clay which is not characteristic for this locality. *Yield:* Abundant. *Use:* Farm purposes and at times for drinking. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Fair; near the stables but reasonably well protected.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House excellent; barn and stables excellent; privy poor.

Milk.—Sold to creamery; sanitary care excellent.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

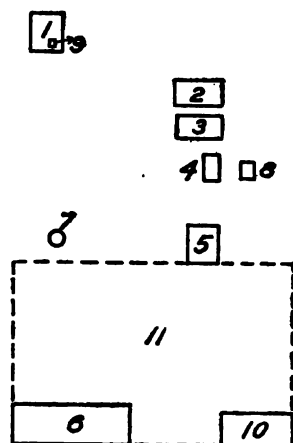


FIG. 14.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 14: 1, House; 2, smokehouse; 3, tool shop; 4, corner; 5, granary; 6, barn and stables; 7, well; 8, hogpen; 9, cistern; 10, barn and stables; 11, barnyard.

No. 16. A polluted supply. By draining the barnyard and outbuildings in another direction, which is possible in this case, and by installing a tight casing and covering this supply could be made satisfactory.

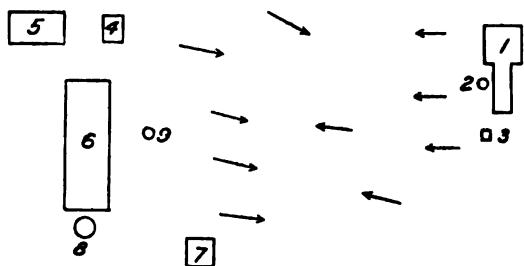


FIG. 15.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 15: 1, House; 2, well; 3, privy; 4, granary; 5, wagon shed; 6, barn and stables; 7, chicken house; 8, silo; 9, well.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—One hundred and thirty-six acres.

Kind of farming.—General.

Topography.—Surface generally level, but barnyard slopes quite abruptly toward the well; about 8 feet difference in elevation between well and surrounding higher ground.

Source of water supply.—(See fig. 16.) Well in barnyard

about 35 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Unknown; judging from other wells in locality, blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; wind-mill used for power. *Sanitary aspect:* Very bad. The entire drainage of the barnyard flows toward the well; puddles surround the well; the mouth is slightly raised but at times surface wash enters.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables and barnyard poor; privy very poor, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 17. A polluted supply. This supply could be made satisfactory by installing a good casing and a tight covering and by trenching and banking the soil around the mouth of the well to turn the flow of surface water in the opposite direction.

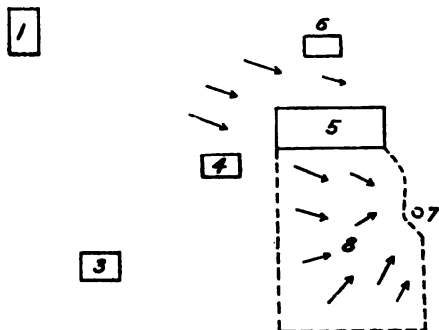


FIG. 16.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 16: 1, House; 2, privy; 3, granary; 4, tool shed; 5, barn and stables; 6, cornercrib; 7, well; 8, barnyard.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—General.

Topography.—Surface level around house and outbuildings.

Source of water supply.—(See fig. 17.) Well very near stables and surrounded by farm buildings; 60 feet in depth; casing, tile. *Strata:* Yellow clay. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. During heavy rains so much surface water enters that well can not be used for several days.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; milk-house fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 18. A polluted supply. This well could unquestionably be made a safe supply by improving the construction of the casing and covering.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—House about 2½ feet above stables; well on same level as house.

Source of water supply.—(See fig. 18.) Well about halfway between house and stables; 28 feet in depth; 3 feet square; casing, wood. *Strata:* Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet, and rock, 8 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Surface covered with loose boards; surface water at times undoubtedly enters; surface drainage away from well except during heavy rains.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stable very poor; privy very poor, open vault, very poorly protected and shows no attention whatever.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 19. A polluted supply. The polluting environment should be removed or a well dug in a better location. In either case a proper covering and a good pump should be installed.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

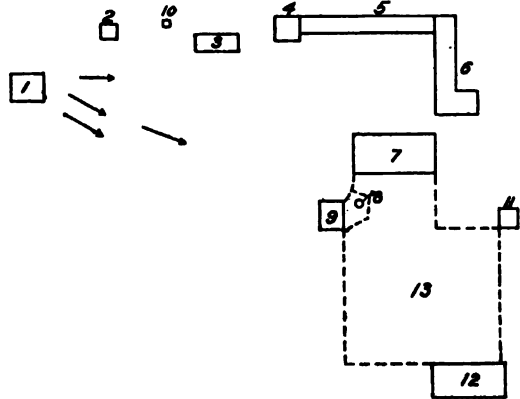


FIG. 17.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 17: 1, House; 2, wood shed; 3, corncrib; 4, granary; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, ice house; 10, privy; 11, tool shed; 12, stables; 13, barnyard.

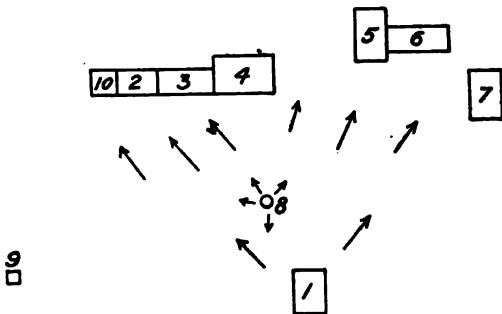


FIG. 18.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 18: 1, House; 2, milk house; 3, cow stable; 4, barn and stables; 5, corncrib; 6, hogpen; 7, granary; 8, well; 9, privy; 10, wood shed.

Size.—Seventy acres.

Kind of farming.—General.

Topography.—The surface surrounding house has been artificially raised about 1 foot above outbuildings; well is on same level as stables and barnyard.

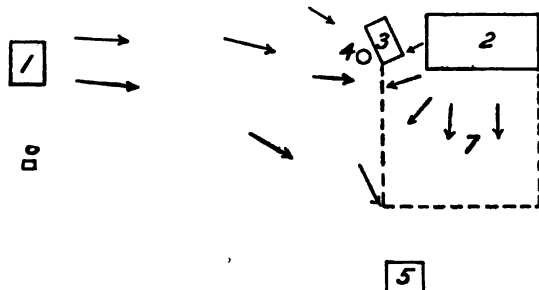


FIG. 19.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 19: 1, House; 2, stable and barn; 3, tool shed; 4, well; 5, wagon shed; 6, privy; 7, barnyard.

Bad, due to the filthy barnyard about 10 feet away. Surface wash is prevented by a 1-foot extension of tile.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, uncared for, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—One case of typhoid in October, 1901; several cases were in the neighborhood about the same time.

Analyses.—See page 78.

No. 20. A polluted supply. It is probable that even the best protection in the way of construction would not preserve the purity of this supply. One should be secured in a better location.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

Size.—Two hundred and thirty-five acres.

Kind of farming.—General.

Topography.—Elevation of ground between house and outbuildings about $1\frac{1}{2}$ feet, with a very gradual slope toward house and stables.

Source of water supply.—(See fig. 20.) Well partly under doorstep of house; 30 feet in depth; casing, cemented stone. *Strata:* Surface soil, 3 feet; remainder clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The house cellar, about 4 feet distant, contained 2 feet of water. Well water has peculiar taste whenever cellar fills, showing that there is chance of pollution from upper strata. This well is undoubtedly dangerous during wet seasons.

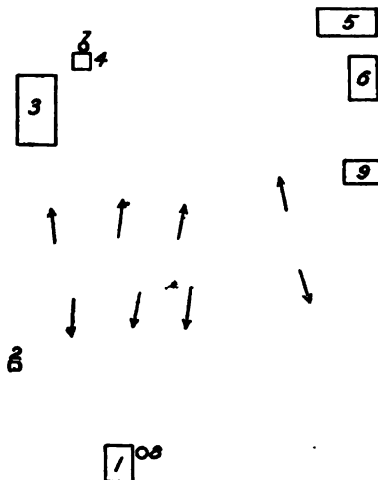


FIG. 20.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 20: 1, House; 2, privy; 3, barn and stables; 4, tool shed; 5, storehouse and cornerrib; 6, granary; 7, cattle well; 8, well; 9, old log house.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good with exception of cellar, which contained water which as fast as pumped out flows in from surrounding saturated earth; stables very good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 21. A good supply. This supply could be improved by installing a tight casing.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—The ground slopes from the house in the direction of the stables, which are about 7 feet lower.

Source of water supply.—(See fig. 21.) Well about 25 feet from house, 50 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Surface soil, 3 feet; clay, 10 feet; gravel, 17 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Mouth of well protected with tight board cover. Privy about 50 feet from well on same level, but vault is well protected.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables excellent; privy good, tightly boxed vault, well protected.

Milk.—Sold to dealer; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

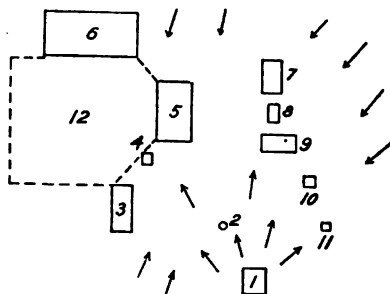


FIG. 21.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 21: 1, House; 2, well; 3, hogpen; 4, stable well and pump house; 5, stable; 6, barn and stables; 7, granary; 8, cornerrib; 9, tool shed; 10, smokehouse; 11, privy; 12, barnyard.

No. 22. A polluted supply. A safe supply could be secured by proper drainage and by improving the casing and covering.

Location of farm.—South Haven, Minn.

Date of visit.—August 14, 1908.

Size.—One hundred and fifty acres.

Kind of farming.—General.

Topography.—The stables and house are on the same level; the well is about 2 feet below. The surface flow from outbuildings and barnyard is partly in the direction of the well.

Source of water supply.—(See fig. 22.) Well about 20 feet from house; 14 feet in depth; casing, 1½-inch wooden planks. *Strata:* Clay, 13 feet, and gravel and sand, 1 foot. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface drainage from house and outbuildings enters in case of heavy rains. Mouth of well is poorly covered with rough boards.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A stagnant pond lies about 50 feet away, but at a much lower level; another stagnant pond is located about 200 feet in opposite direction from well.

Sanitary conditions of farmhouse and outbuildings.—House and stables poor; privy very poor, open vault, unprotected and shows entire lack of care.

Milk.—Entire supply made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid fever, a young woman 20 years old, occurred

on the place during the early spring of 1908. She had made several visits to neighbors, but no record of any cases could be found among the people she visited. It is impossible with the data at hand to locate the source of infection.

Analyses.—See page 78.

No. 23. A polluted supply. This supply if protected could be improved, but probably could not be made safe.

Location of farm.—St. Cloud, Minn.

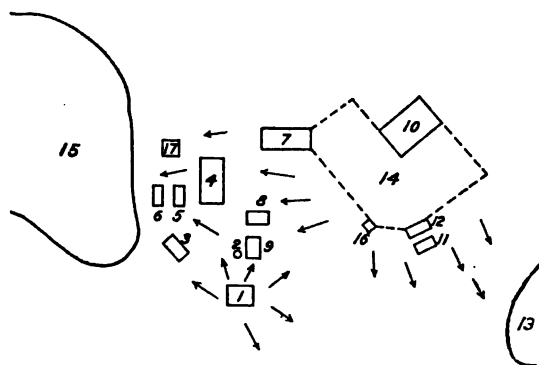


FIG. 22.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 22: 1, House; 2, well; 3, tool shed; 4, granary; 5, corncrib; 6, corncrib; 7, wagon shed; 8, smokehouse; 9, tool shed; 10, stables; 11, chicken house; 12, corncrib; 13, pond; 14, barnyard; 15, pond; 16, privy; 17, hogpen.

Date of visit.—August 14, 1908.

Size.—Two hundred and forty-eight acres.

Kind of farming.—General.

Topography.—The ground surrounding the farmhouse and outbuildings is very level.

Source of water supply.—(See fig. 23.) Well about 26 feet from house; 44 feet in depth; casing, brick. *Strata:* Clay, hardpan, gravel, and sand. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The mouth of the well is poorly covered with rough boards and receives surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid on this place some eighteen years previous to visit.

Analyses.—See page 78.

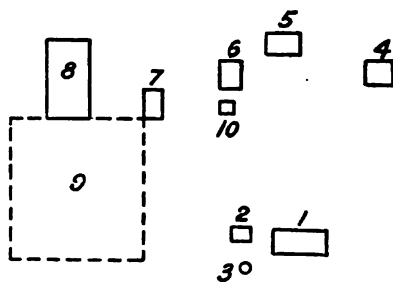


FIG. 23.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 23: 1, House; 2, smokehouse; 3, well; 4, granary; 5, chicken house; 6, corncrib; 7, corncrib; 8, barn and stables; 9, barnyard; 10, privy.

No. 24. A polluted supply. This supply could be made very satisfactory by installing a good casing and tight covering.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Ground surrounding house and outbuildings is quite level. Well is located on same level as stables, but 1 foot below level of house.

Source of water supply.—(See fig. 24.) Well about 70 feet from house; 25 feet in depth; 3 feet square; casing, wood. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Surface wash and back flow from pump enter freely. Large fungous growths project from the sides of well at surface of water. Well is used for cooling milk and other articles of food.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables poor; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—One case of typhoid, a farm hand, appeared on this place August 7, 1908. The patient had not used water from any other source for over a month. This being the busy harvest season, the man had been confined closely to work for over a month and recalled no trips away from home except a visit now and then to near neighbors. At that time no other cases were present in the immediate vicinity. One case of typhoid was located some 3 miles from this farm, but no communication whatever could be traced from this source to the patient or to any of the near neighbors. The patient lays the source of his infection to the well, but although the sanitary surroundings of the well are bad, it would be impossible to fix this as the infecting agent without more definite information.

Analyses.—See page 78.

No. 25. A polluted supply. This supply could be made safe by installing a good casing and adding the necessary surface protections.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

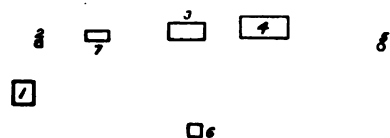


FIG. 25.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 25: 1, House; 2, privy; 3, granary; 4, stables; 5, well; 6, tool shed; 7, chicken coop.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie; no natural slopes drain the surface in any direction.

Source of water supply.—(See fig. 25.) Well about 50 feet from stable; 40 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. The covering admits both surface wash from barnyard and back flow from pump; casing broken in many places. Pieces of wood, fungous growths, and other decomposing organic materials were floating on surface of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None permanent.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, open vault with very little protection.

Milk.—Made into butter and sold in Crookston; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 26. A polluted supply. As there are many other much more favorable locations within a few rods, it would be better to relocate than to attempt to improve the structure materially.

Location of farm.—Huot, Minn.

Date of visit.—September 11, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—House and outbuildings located on level land with a very gradual slope in the direction of the river and also away from the river. House about 25 feet above Red Lake River. The slope right at river bank is very abrupt.

Source of water supply.—(See fig. 26.) Well about 20 feet from river and 10 feet above river bed; 12 feet in depth; casing, boards. *Strata:* Sand, gravel, and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface wash from steep bank above flows directly into well. On date of visit well contained all sorts of organic material, both

living and dead. The pump being out of order, a pail and rope were used. The first pail drawn contained two frogs, numerous bugs, sticks, grass, and considerable mud. The people on the farm continue to drink the water.

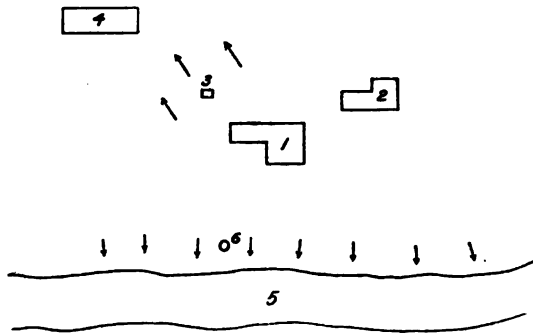


FIG. 26.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 26: 1, House and general store; 2, stables; 3, privy; 4, beehouse; 5, Red Lake River; 6, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River flows by edge of farm. The river water is used for drinking purposes during the winter season.

Sanitary condition of farm-house and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

Milk.—Buy milk from creamery.

Water-borne diseases.—One case of typhoid occurred on this farm during the spring of 1908. A man, aged 38, was taken ill April 1. The patient had been at home for some time previous to the infection and had taken care of his brother, who contracted the disease February 28. He drank water from the river entirely from November 15 to date of illness. This case may be one of infection from the river water or by contact in caring for his brother during his illness.

Analyses.—See page 78.

No. 27. A polluted supply. This supply could be very much improved by installing a good casing, by banking the surface to carry away surface water, and by the installation of a pump.

Location of farm.—Thief River Falls, Minn.

Date of visit.—September 14, 1908.

Size.—One hundred and forty-five acres.

Kind of farming.—Grain.

Topography.—Surface on which farm buildings are located is level prairie land.

Source of water supply.—(See fig. 27.) Well about 20 feet from house; 13 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Bad. Well receives surface wash from all directions; mouth surrounded with decomposing straw. The well is used to cool food products, and just before date of visit a can of milk had been spilled into it; odor and appearance of water very bad. The utensils used in drawing water were very dirty.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected. This is really a primitive farm and has been occupied only three years.

Milk.—Made into butter and sold in Thief River Falls; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 28. A polluted supply. This supply could be improved by completing the casing and making a tight cover.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—General.

Topography.—Buildings are on level prairie. Drainage from farm buildings by artificial means reaches the Middle Branch River.

Source of water supply.—(See fig. 28.) Well about 40 feet northeast of house; 18 feet in

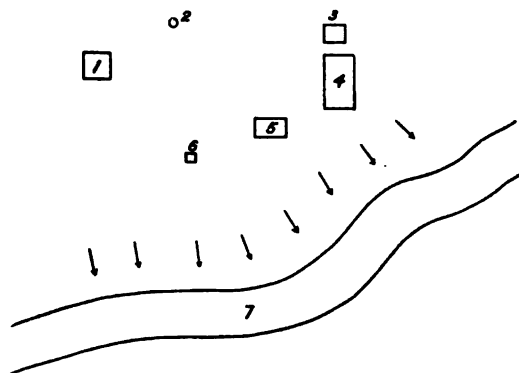


FIG. 28.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 28: 1, House; 2, well; 3, granary; 4, stables; 5, tool shed; 6, privy; 7, Middle Branch River.

house and outbuildings.—House poor; stables fair; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.



FIG. 27.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 27: 1, House; 2, privy; 3, stable; 4, well.

depth; casing, 10 feet brick and 8 feet boards. *Strata:* Surface loam, 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet. *Yield:* Insufficient during months of March and April. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and bucket. *Sanitary aspect:* Bad. Mouth of well covered with loose boards; surface wash enters freely.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Middle Branch River flows near house.

Sanitary condition of farm-

BORED WELLS.

No. 1. A polluted supply. This supply could be made safe by installing a tight casing and good covering.

Location of farm.—Chikio, Minn.

Date of visit.—August 10, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—The ground on which the house and outbuildings are located is level.

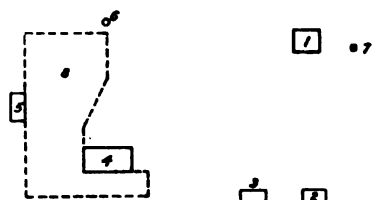


FIG. 29.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 1: 1, House; 2, granary; 3, tool shed; 4, barn and stables; 5, hogpen; 6, well; 7, privy; 8, barnyard.

Source of water supply.—(See fig. 29.) Well about 50 feet from stables and at corner of barnyard; 55 feet in depth; casing, board, 1½ feet in diameter. *Strata:* Clay, 40 feet; sand and gravel, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; too near barnyard. Mouth of well is raised 2½ feet above surrounding surface; board covering in poor repair.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables good; privy very poor, open vault and unprotected.

Milk.—Sold to butter factory; sanitary care fair.

Water-borne diseases.—One case of typhoid, July 15, 1908. The patient, a hired man, had not visited Morris or any of the surrounding villages for some time previous to infection, which could not be traced. No other people on the farm became infected.

Analyses.—See page 78.

No. 2. A polluted supply. The installation of a good casing and the proper draining or the removal of the barnyard would make this a satisfactory supply.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

Topography.—Surface adjacent to farm buildings quite level. The house, however, is elevated about 1 foot above the level of the well; drainage from the house would be in the direction of the well and stables.

Source of water supply.—(See fig. 30.) Well several feet from barnyard; 27 feet in depth; no casing. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Location near barnyard and on same level makes contamination from that source possible. Surface wash and back flow from pump enters well freely. Occasionally water has a bad taste, which is probably due to wash from barnyard.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

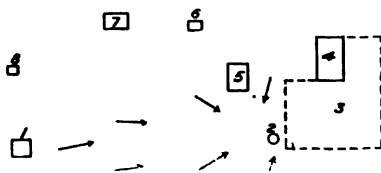


FIG. 30. Sketch showing the topography and the location of buildings in the vicinity of bored well No. 2: 1, House; 2, well; 3, barnyard; 4, barn and stables; 5, granary; 6, tool shed; 7, chicken house; 8, privy.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy very poor, open vault and entirely unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A badly polluted supply. This supply could be rendered fit for use by installing a pump and protecting the well from surface pollution.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding buildings about 12 feet above the bed of Snake River; very level with the exception of an abrupt fall 50 feet from the house toward the river.

Source of water supply.—(See fig. 31.) Well about 30 feet from house; 10 feet in depth; casing, 6-inch tin pipe. *Stratum:* Blue prairie clay. *Yield:* Abundant except during dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Tin bucket with a loose bottom. *Sanitary aspect:* Very bad. One bucket of water contained frogs, bugs, sticks, straw, and mud. The covering of the top of a milk can, which evidently is used only when the water becomes unusually filthy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One river.

Sanitary condition of farmhouse and outbuildings.—House very poor, a disgusting odor making it almost impossible to remain inside; stable very poor; privy very poor, open vault and entirely unprotected.

Milk.—The entire supply is used by the family; sanitary care very poor, all utensils filthy.

Water-borne diseases.—Six cases of typhoid fever occurred in this family during the spring months of 1908: A girl, age 18 years, taken ill March 25; a boy, 12 years, April 15; a boy, 8 years, May 26; a girl, 15 years, May 30; a woman, 41 years, May 31; a boy, 18 years, June 1. The original case of this infection was brought from Oslo, Minn., where the girl had been employed in a hotel as a servant. The other cases were probably infected by contact, although the well, also, might have been a means of carrying the infection.

Analyses.—See page 78.

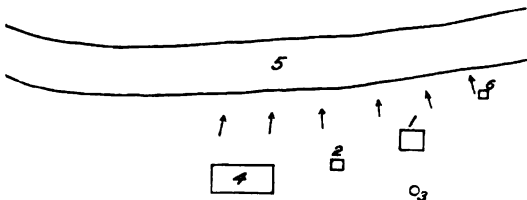


FIG. 31.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 3: 1, House; 2, tool shed; 3, well; 4, stables; 5, Snake River; 6, privy.

No. 4. A badly polluted supply. The sanitary condition of this supply could be improved by proper surface protection, and by installing a good pump the water could be made safe as long as the tin casing remained in good condition.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding farm buildings is level prairie.

Source of water supply.—(See fig. 32.) Well about 50 feet south of house; 13 feet in depth; casing, 6-inch tin pipe. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general house purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Poor. This well is so situated that it receives surface wash whenever precipitation is sufficient to cover the surface. No covering is used for protection, so the water necessarily receives considerable surface dust and organic pollution.

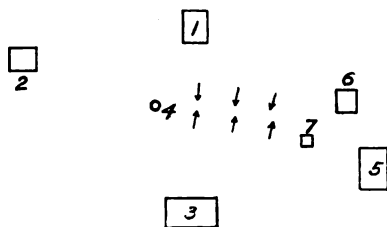


FIG. 32.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 4. 1, House; 2, granary; 3, stables; 4, well; 5, chicken house; 6, tool shed; 7, privy.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. Probably a good supply. The supply should be farther from the outbuildings.^a

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house and barn; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth; 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; barn poor.

Milk.—Occasionally supplied summer residents in the neighborhood; sanitary care poor.

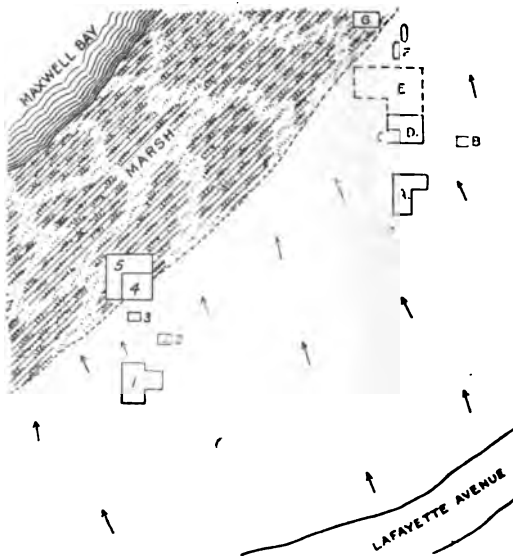


FIG. 33.—Sketch showing the topography and the location of buildings in the vicinity of bored wells Nos. 5 and 6: A, House of farm No. 5; B, well; C, privy; D, barn and wood shed; E, chicken yard; F, haystacks; G, ice house. 1, House of farm No. 6; 2, well; 3, privy; 4, horse and cow stables; 5, chicken yard.

^a Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Water-borne diseases.—Two cases of typhoid fever, the first, a man 32 years old, taken sick September 11, 1908, and the second, a girl 10 years old, taken sick October 20. Source of infection for first case, Minneapolis; for second, contact or infected milk. *Analyses.*—See page 78.

No. 6. Probably a good supply. The supply should be farther from the outbuildings.^a

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house, privy, and stables; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth, 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stable poor.

Milk.—Obtained from neighbor three-fourths mile away, except about 5 quarts, taken at different times, from next door (see No. 5, fig. 33).

Water-borne diseases.—Two cases of typhoid fever; first, a girl 15 years old, taken sick October 13, 1908; second, a boy 10 years old, taken sick October 18. Source of infection, milk or contact.

Analyses.—See page 78.

DRILLED WELLS.

No. 1. A polluted supply. The pollution may be due to surface water following the iron pipe to the point where it touches the rock and possibly gaining entrance there, but is more probably due to leaks in the cistern holding well water a short distance away. Both well and cistern should be protected from surface wash and seepage from the upper strata.

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Eighteen acres.

Kind of farming.—Dairy.

Topography.—All the buildings are on a steep incline.

Source of water supply.—(See fig. 34.) Well in barnyard; 138 feet in depth; casing, 6-inch iron pipe to a depth of 17 feet, remainder rock. *Strata:* Clay, 17 feet; remainder limestone rock. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, horse sweep used for power. *Sanitary aspect:* Fair. Well in center of barnyard below level of stable. Casing attached to pump.

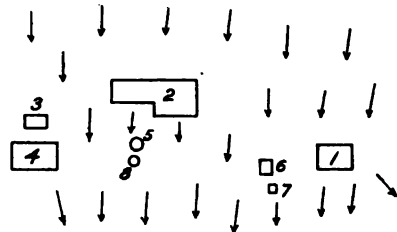


FIG. 34.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 1: 1, House; 2, stables; 3, corner; 4, hay shed; 5, well; 6, chicken house; 7, privy; 8, cistern (well).

^a Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Cisterns.—Two. A cement cistern used to hold surplus supply for cattle is located in barnyard near pump. This cistern is evidently very badly polluted, as the water is discolored and has a very unpleasant odor. The house cistern is used for washing purposes and for cooling milk.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Retailed in Red Wing; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A badly polluted supply. The practice of using an unprotected dug well as a surface reservoir is undesirable, to say the least. It is an open question whether this supply is responsible for the three typhoid fever cases on the farm.

Location of farm.—St. Peter, Minn.

Date of visit.—July 27, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

Topography.—The ground immediately surrounding the house has been artificially raised about 6 inches to turn surface wash.

Source of water supply.—(See fig. 35.) Well about 35 feet from house; 167 feet in depth, dug 25 feet and drilled 142 feet; casing, 2-inch iron pipe; well pit, 25 feet deep, cased with uncemented stone. *Strata:* Surface soil and clay.

Yield: Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Very bad. The well pit is used as a supply tank, the water being pumped out of the deep well by a windmill into the well pit. The mouth of the pit is very poorly protected with loose boards, which are lower than surrounding surface. During

heavy rains water runs freely into well pit, and the privy, which is 75 feet away, undoubtedly contributes to the surface wash which finally reaches the well pit.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Shallow puddles during wet season, no permanent ponds.

Sanitary condition of farmhouse and outbuildings.—House good; barn fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—Three positive cases of typhoid fever, a man and a woman taken sick July 7, 1908, and a woman taken sick July 17. The history of these cases shows visits to St. Peter; only one of these patients drank city water, however, and she was taken sick three days later, which allows too short a period for the incubation of the disease. No other cases of typhoid have been reported recently among the users of city water. No other cases have been reported in the rural districts in that vicinity, nor have any of the patients visited homes or associated with people known to have typhoid. All the patients were users of the farm water supply.

Analyses.—See page 78.

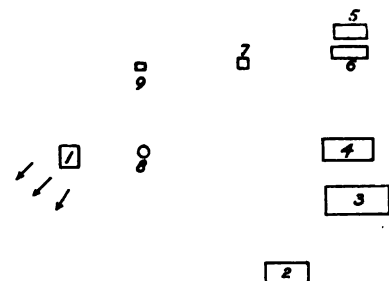


FIG. 35.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 2: 1, House; 2, granary; 3, stables; 4, chicken house; 5, cornerb; 6, cornerb; 7, smokehouse; 8, well; 9, privy.

No. 3. A polluted supply. Extra precautions should be taken in the case of this well to cover the casing properly and avoid the inflow of back wash from the pump, which at times may cause a serious pollution.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—Gradual slope from the house toward the stables; difference in elevation between house and stables about $2\frac{1}{2}$ feet.

Source of water supply.—(See fig. 36.) Two wells (No. 3 and No. 10). Well No. 3, near stables, 107 feet in depth; casing, 6-inch iron pipe. *Strata:* Blue clay and small quantity of rock. *Yield:* Abundant. *Use:* For cattle only. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. This well is quite near stables and barnyard, but its depth and especially good surface protection will undoubtedly keep it free from pollution. Well No. 10, about 50 feet from house, 100 feet in depth, dug 40 feet and drilled 60 feet; casing, stone in dug portion, 6-inch iron pipe in drilled portion. *Strata:* Blue clay and 10 feet of rock at bottom. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Except in cases of heavy rains there is little opportunity for surface wash.

Cisterns.—One, used for drinking water.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—One case of typhoid, taken sick April 11, 1908. The patient claims to have drunk no water except from well No. 10. In one other case of typhoid, about a mile and a half from this farm, the patient had just recovered. Neither patient admits having visited the other at any time previous to infection.

Analyses.—See page 78.

No. 4. A polluted supply. This supply offers good opportunity for occasional serious pollution due to improper construction. The sanitary condition of the water could undoubtedly be improved by extending the casing to the base of the pump, by properly protecting the well pit, or by covering the mouth of the casing with a tight cover.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—Difference in elevation between house and granary about 8 feet; well located on level with house and stables.

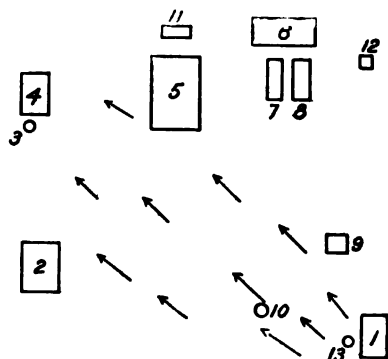


FIG. 36.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 3: 1, house; 2, stables; 3, well; 4, stables; 5, granary; 6, henhouse; 7, corncrib; 8, corner; 9, smokehouse; 10, well; 11, hogpen; 12, privy; 13, cistern.

Source of water supply.—(See fig. 37.) Well near corner of barn; 90 feet in depth; casing, 6-inch iron pipe; well pit 10 feet deep, cased with boards. *Strata:* Clay, 40 feet; remainder gravel and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Very near stables and surface wash sometimes fills the well pit. The iron casing does not extend to the pump, so when the pit is full

this surface water may enter the well directly.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—One case of typhoid, a man, taken sick October 12, 1908.

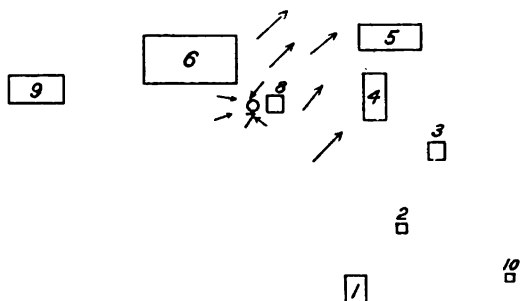


FIG. 37.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 4: 1, House; 2, wood shed; 3, smokehouse; 4, chicken house; 5, granary; 6, barn and stables; 7, well; 8, milk house; 9, hogpen; 10, privy.

No other cases were known to be in the neighborhood at that time. Patient previously had visited a great many farms with a thrashing crew.

Analyses.—See page 78.

No. 5. A polluted supply. This pollution is due chiefly to inflow of water from the dug portion directly into the deep well casing. The water could be greatly improved by extending the casing, then filling part of the dug portion—say, to within 10 feet of the surface and using this as a well pit—and carefully installing means of excluding surface pollution.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and eighty-five acres.

Kind of farming.—General.

Topography.—Difference in elevation between house and stables about 3 feet; slope from house toward stables; stables on same level as well.

Source of water supply.—(See fig. 38.) Well in barnyard near stables; 60 feet in depth, dug 30 feet and drilled 30 feet; casing, dug portion uncemented stone, drilled portion 3-inch iron casing. *Strata:* Sand and clay, 30 feet; remainder limestone. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Mouth of well covered with loose boards. Surface immediately around well has been raised, but not enough to prevent surface wash into the casing of drilled portion at times.

Cisterns.—One, used for washing.

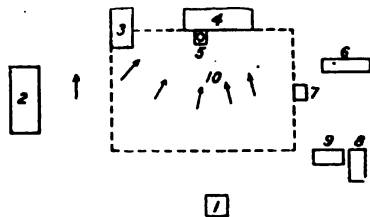


FIG. 38.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 5: 1, House; 2, barn and stables; 3, stables; 4, stables; 5, well and milk house; 6, chicken house; 7, granary; 8, wood and wagon shed; 9, tool shed; 10, barnyard.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables very poor; milk house very poor; privy poor, unprotected vault.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 6. A polluted supply. The protection of this well is apparently good, yet the water is evidently polluted. The bad location of the well and the poor protection of the mouth of the well may be responsible for this pollution. It is also possible that pollution is drawn from some underground source, as the well and the lake have about the same level.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—One hundred and forty-one acres.

Kind of farming.—General.

Topography.—A small creek separates house from most of the outbuildings. The depression formed by creek is very narrow, but about 6 feet deep. Lake Andrews is located about 40 rods from house and at a level 15 or 20 feet lower.

Source of water supply.—(See fig. 39.) Well about 25 feet from house; 80 feet in depth; casing, 3-inch iron pipe attached to base of pump. *Strata:* Gravel, 10 feet; few feet red clay; 50 feet blue clay; and 10 feet of sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Mouth of well several feet below level of house and of surrounding ground; covering very poor.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Lake Andrews 40 rods away; flowing spring near stables; small creek leading from spring to lake.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 7. A polluted supply. The location of the well is bad, yet with good surface protection the supply might be made safe.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—Two hundred and twenty acres.

Kind of farming.—General.

Topography.—The house is elevated slightly above level of stables; other outbuildings on same level with house. The surface slopes very abruptly from stables on side away from house. Drainage from stables and barnyard empties into a pond about 8 rods distant.

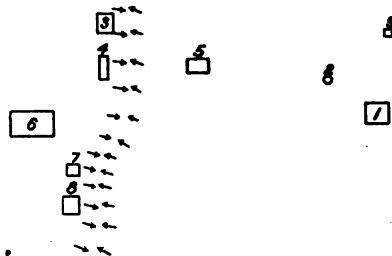


FIG. 39.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 6: 1, House; 2, well; 3, hogpen; 4, corncrib; 5, chicken coop; 6, barn and stables; 7, granary; 8, toolshed; 9, privy.

Source of water supply.—(See fig. 40.) Well about 15 feet from house; 60 feet in depth; casing, iron pipe. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad; too near privy. Covering in poor condition; waste water from pump sinks into ground around the casing.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Several ponds.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—About one year previous to date of visit an infection of typhoid occurred on this farm and gave rise to eight cases of typhoid. The attending physician lays the source to a shallow well then in use by the family, which has since been filled.

Analyses.—See page 78.

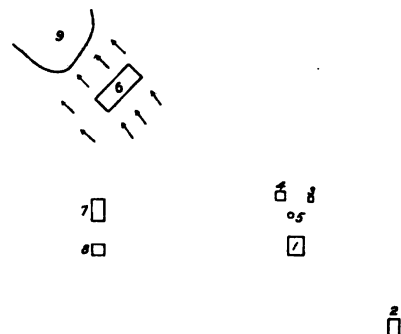


FIG. 40.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 7: 1, House; 2, ice house; 3, privy; 4, outdoor kitchen; 5, well; 6, barn and stable; 7, wagon shed; 8, granary; 9, pond.

No. 8. A good supply. If the well pit was tightly cased it would give greater protection against back wash from the pump and inflow from the upper strata.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—Three hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 2 feet above granary and well and about 4 feet above barn.

Source of water supply.—(See fig. 41.) Well about 40 feet from house; 153 feet in depth; casing, 4-inch iron pipe; well pit about 3 feet square, 10 feet deep, cased with boards. *Strata:* Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet; and about 5 feet of sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good. Mouth of well protected by tight covering. A small quantity of back flow enters well pit as drainage from pump cylinder.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

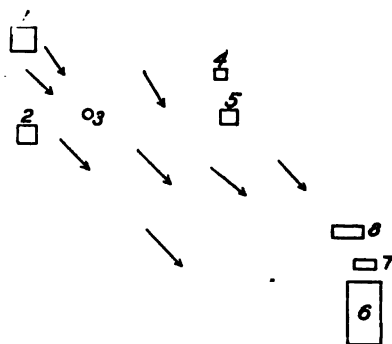


FIG. 41.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 8: 1, House; 2, granary; 3, well; 4, privy; 5, ice house; 6, barn and stables; 7, corncrib; 8, hogpen.

No. 9. A good supply.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

Size.—Two hundred and forty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 42.) Well in combination ice and pump house; 200 feet in depth; casing, 2-inch iron pipe. *Strata:* Blue clay. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good.

A double board covering protects the 10-foot well pit from surface wash and back flow, and casing extends to base of pump. More than the usual precautions are observed in protecting this well.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy has open vault, slightly protected.

Milk.—Sold in Crookston; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

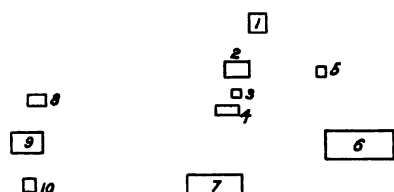


FIG. 42.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 9: 1, House; 2, woodshed; 3, privy; 4, chicken house; 5, well and ice house; 6, stables; 7, machine shed; 8, chicken coop; 9, machine shed; 10, hogpen.

No. 10. A polluted supply. The field observations show this to be a more offensively polluted water than is indicated by the analytical data. By carefully protecting the mouth of the well with a good covering and discontinuing the use of the well pit as a refrigerator the supply could be rendered safe.

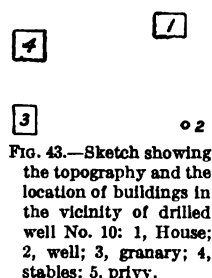


FIG. 43.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 10: 1, House; 2, well; 3, granary; 4, stables; 5, privy.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 43.) Well about 50 feet from stables; 180 feet in depth; casing, 2-inch iron pipe.

Strata: Unknown, probably blue clay. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The 2-inch iron casing is carried to within 14 feet of surface and there empties its

overflow into a well pit, which is cased with an iron casing about 2½ feet in diameter. The well pit contained several feet of water, on which were floating decomposed cream and other contaminations of surface origin.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—Two cases of typhoid fever occurred during the summer of 1898.

The same water supply was used at that time. The family having moved away, no definite data could be found regarding these cases.

Analyses.—See page 78.

No. 11. A polluted supply. The city of Crookston is located several miles from this farm, and a well sunk there for a municipal supply drained the well under discussion. This would seem to indicate that this well is connected with an extensive underground supply which may be polluted at a more or less distant point. Without considerable investigation it would be impossible to determine whether or not this supply is perfectly safe.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

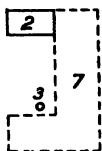
Topography.—Level prairie.

Source of water supply.—(See fig. 44.) Well about 30 feet from corner of stables; 203 feet in depth; casing, 2½-inch iron pipe.

□ 6

□ 5

□ 1



□ 4

FIG. 44.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 11: 1, House; 2, stables; 3, well; 4, chicken house; 5, granary; 6, privy; 7, barnyard.

Strata: Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; and fine sand, 3 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; near barnyard and stable, yet for a well as deep and as carefully protected as this one little danger could be expected from that source. Casing extends to base of pump. Water rises to within 17 feet of surface.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and out-buildings.—House poor; stables very

poor; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 12. A polluted supply. Although the surface protection of this well is good, the environment is bad; the pollution is probably due to seepage from the upper strata down the outside of the casing. For domestic use a well should be sunk farther from the stables and barnyard.

Location of farm.—Hallock, Minn.

Date of visit.—September 17, 1908.

Size.—Four hundred and eighty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 45.) Well about 5 feet from stables; 75 feet in depth; casing, 2½-inch iron pipe. *Strata:* Hardpan and a clay mixture. *Yield:* Abundant, except in very dry seasons. *Use:* Drinking, when the supply of cistern water gives out, and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair; too near stables. Surface of well is thoroughly protected from surface wash and back flow.

Cisterns.—One, used for drinking, but was empty on date of visit.

Lakes, rivers, ponds, and springs.—A few ponds, dug for collecting surface water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 13. A good supply. It is advisable to prevent collection of water in the well pit.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—Level, sandy surface. Drainage is carried artificially in several directions.

Source of water supply.—(See fig. 46.) Well in pump house about 25 feet from house; 112 feet in depth; casing, 3-inch iron pipe; well pit 10 feet in depth, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, gasoline engine used for power. *Sanitary aspect:* Good. Well is protected from surface wash, yet a small quantity of back flow enters well pit; about 1 foot of water in well pit on date of visit. Casing extends to base of pump, so there is no opportunity for direct pollution.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house good; privy good, open vault quite well protected.

Milk.—Cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

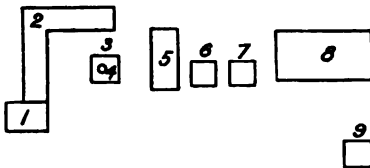


FIG. 46.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 13: 1, House; 2, wagon shed; 3, pump house; 4, well; 5, chicken house; 6, granary; 7, granary; 8, barn and stables; 9, granary.

Location of farm.—Excelsior, Minn.

Date of visit.—June 30, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—Surface is irregular, sloping gradually toward the creek. The low, flat land surrounding the elevation is subject to overflow during the spring season.

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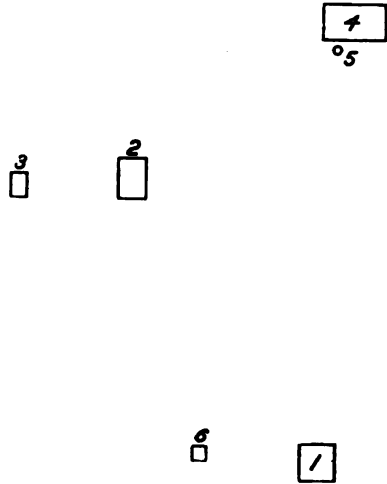


FIG. 45.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 12: 1, House; 2, feed house; 3, chicken house; 4, barn and stables; 5, well; 6, privy.

from surface wash, yet a small quantity of back flow enters well pit; about 1 foot of water in well pit on date of visit. Casing extends to base of pump, so there is no opportunity for direct pollution.

DRIVEN WELLS.

No. 1. A good supply, except for the temporary pollution of the storage tank.

Source of water supply.—(See fig. 47.) Well about 30 feet from house; 150 feet in depth; casing, 3-inch iron pipe. *Strata:* Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:*

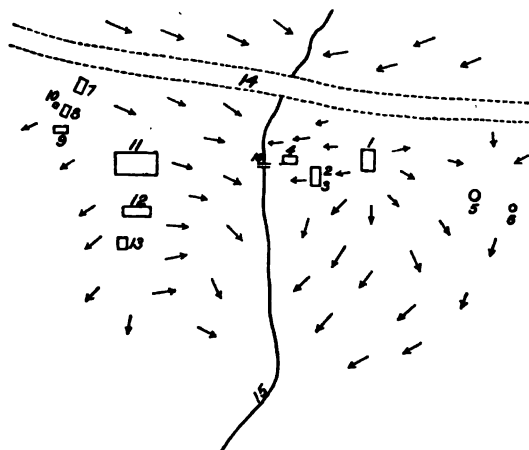


FIG. 47.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 1: 1, House; 2 and 3, pump house and elevated water tank; 4, ice house; 5, cesspool; 6, cesspool outlet; 7, farmhouse; 8, shed; 9, chicken coop; 10, privy; 11, barn; 12, shed; 13, corner; 14, road; 15, creek; 16, bridge.

Iron pump with windmill and gasoline engine for power. Storage tank: Wood, capacity 3,800 gallons. *Sanitary aspect:* Good. The well pit is dry and well protected from surface wash. A short time before date of visit the storage tank began to leak and the owner emptied several pecks of meal into the tank. The meal soon decomposed and gave the water a bad taste and odor. The cesspool is a considerable distance from the well.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—One lake, several springs, and one creek on farm.

Sanitary condition of farmhouse and outbuildings.—House very good; stables fair; privy good, connected with cesspool.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—For both well water and tank water, see page 79.

No. 2. A polluted supply. This could be made a safe supply by protecting the well pit from surface wash.

Location of farm.—New Brighton, Minn.

Date of visit.—July 3, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The land in general slopes away from the house and outbuildings and toward the well. The yard and basements of stables are approximately 6 feet lower than surface of well.

Source of water supply.—(See fig. 48.) Well surrounded by farm buildings;

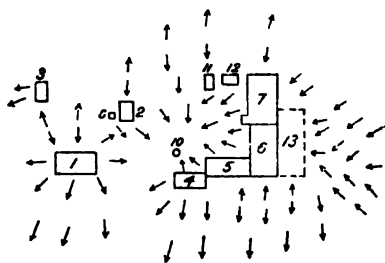


FIG. 48.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 2: 1, House; 2, ice house; 3, tool shed; 4, hay barn; 5, hay barn; 6, hay barn; 7, stables; 8, privy; 9, public road; 10, well; 11, corner; 12, corner; 13, barnyard.

well protected at surface. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Fair. Slope toward well very gradual; in wet weather well pit fills with water.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 3. A polluted supply. This well is in as bad a location as could be found on the farm and should be abandoned.

Location of farm.—St. Louis Park, Minn.

Date of visit.—July 6, 1908.

Size.—Sixty acres.

Kind of farming.—Dairy.

Topography.—The land surrounding buildings slopes abruptly from house and outbuildings in direction of stable and well. Well is about 3 feet lower than stable and 25 feet lower than house.

Source of water supply.—(See fig. 49.) Well is 10 feet from corner of stable; 60 feet in depth; casing, 2-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Very bad. Well is surrounded by manure heaps. The well pit, which is 10 feet deep, contained about 6 feet of manure leachings and surface wash; it sometimes completely fills. It seems that a worse location could scarcely be chosen for a well to be used for drinking purposes.

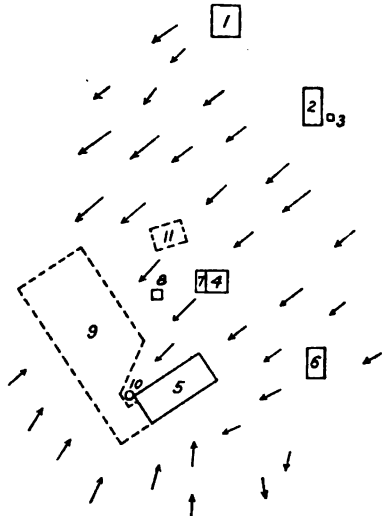


FIG. 49.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 3: 1, House; 2, storehouse and tool shed; 3, privy; 4, ice house; 5, stable; 6, chicken coop; 7, milk room; 8, hogpen; 9, barnyard; 10, well; 11, hay yard.

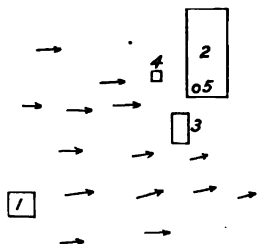


FIG. 50.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 4: 1, House; 2, barn and stable; 3, milk house; 4, privy; 5, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A few ponds scattered about the farm.

Sanitary condition of farmhouse and outbuildings.—House very poor; milk house very bad; privy poor, unprotected vault.

Milk.—Retail in city; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 4. A polluted supply. Both well and stables should be removed to higher ground.

Location of farm.—Minneapolis Minn.

Date of visit.—July 8, 1908.

Size.—One hundred and eighty acres.

Kind of farming.—Dairy.

Topography.—The surface falls abruptly from house to stable, a difference in elevation of about 20 feet.

Source of water supply.—(See fig. 50.) Well in corner of cow stables; 20 feet in depth, driven 10 feet and dug 10 feet; casing, wood and iron. *Strata:* Surface soil, 3 feet;

and sand, 17 feet; a ledge of rock forms bottom of well. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and gasoline engine. *Sanitary aspect:* Very bad. The well pit usually contains from 1 to 2 feet of washings from under stable floor and back flow from pump.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; privy poor, unprotected vault.

Milk.—Retailled in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. By good surface protection the condition of the water could be much improved, though for domestic use a well should be sunk in a more sanitary location.

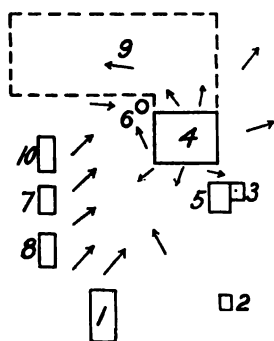


FIG. 51.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 5: 1, House; 2, privy; 3, corncrib; 4, barn and stables; 5, milk house and storehouse; 6, well; 7, stone house; 8, icehouse; 9, barnyard; 10, wagon shed.

Location of farm.—Richfield, Minn.

Date of visit.—July 10, 1908.

Size.—Ninety acres.

Kind of farming.—Dairy.

Topography.—Drainage from most of the outbuildings finally reaches the barnyard at several points near the well.

Source of water supply.—(See fig. 51.) Well about 10 feet from corner of stables and same distance from barnyard; 50 feet in depth; casing, 1½-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. Seepage and surface water from all directions flows directly into the well pit, sometimes standing several feet deep. The water pumped from the well had a decided odor.

Cisterns.—One, under house, but not used.

Lakes, rivers, ponds, and springs.—Lake Grass, a small shallow lake used only to water cattle.

Sanitary condition of farmhouse and outbuildings.—

House fair; milk house poor; stables poor; privy poor, unprotected vault.

Milk.—Retailled in Minneapolis; sanitary care poor.

Water-borne diseases.—Last year three typhoid patients were cared for on this farm but all lived in Minneapolis when taken with the disease. The data at hand indicate that the typhoid was contracted in the city. It seems strange that the disease did not spread to those living on the farm.

Analyses.—See page 79.

No. 6. A good supply. There are other places in this yard that would be more suitable for the water supply.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 10, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 5 feet above the outbuildings. The drainage from most of the outbuildings is in the direction of the pond in the barnyard.

Source of water supply.—(See fig. 52.) Well within a few feet of barnyard and about 15 feet from barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sandy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump; windmill for power. *Sanitary aspect:* Fair. The barnyard and other outbuildings form a rather dangerous environment. The surface of the well is quite well protected and the well pit was perfectly dry on date of visit.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Lake Wood, used at times to water cattle.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 7. A polluted supply. Good protection against surface wash and seepage from the upper strata would greatly improve this supply. It is too near the stable, however.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Three acres.

Kind of farming.—Dairy.

Topography.—Low, level ground.

Source of water supply.—(See fig. 53.) Well in combined pump and milk house; 30 feet in depth; casing, 1½-inch iron pipe. *Strata:* Unknown; probably sandy loam.

Yield: Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill for power. *Sanitary aspect:* Bad. A well pit 3 feet square cased with ordinary wood casing extends to a depth of about 8 feet and contains several feet of surface wash and back flow from the pump. The mouth of the well pit is at a lower level than the stables and the house.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; milk house fair; privy poor, unprotected vault.

Milk.—Retail in St. Paul; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 8. A polluted supply. This supply could be made safe by installing a tight casing for the well pit and fitting a good cover around the base of the pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Ten acres.

Kind of farming.—Dairy.

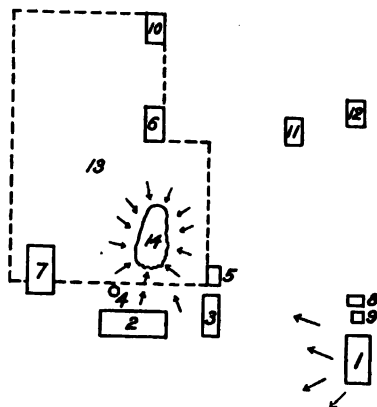


FIG. 52.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 6; 1, House; 2, horse barn; 3, corner; 4, well; 5, ice house; 6, granary; 7, cow stables; 8, wood shed; 9, privy; 10, sheep shed; 11, stone house; 12, storehouse; 13, barnyard; 14, pond.

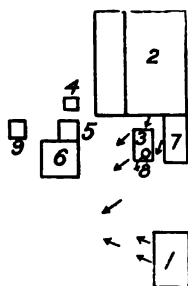


FIG. 53.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 7; 1, House; 2, hay barn and stables; 3, milk house; 4, privy; 5, stone house; 6, wood shed; 7, wagon shed; 8, well; 9, tool shed.

Topography.—The surface slopes very abruptly from the points marked *x* (see fig. 54) in the direction of the outbuildings which are located on the level marked *y*. The difference in elevation between *x* and *y* is about 25 feet; a fall of probably 6 feet was noted between points *y* and *z*. The house and privy are located at a point intermediate between *x* and *y*, probably 15 feet above the other outbuildings.

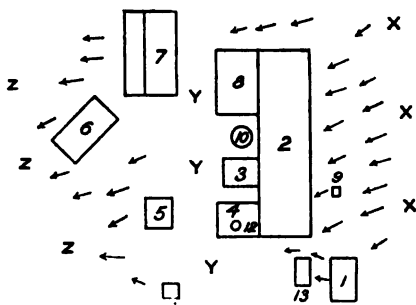


FIG. 54.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 8: 1, House; 2, cow stables; 3, horse stables; 4, well and tank house; 5, stone house; 6, storehouse; 7, cow stables; 8, hay shed; 9, privy; 10, silo; 11, old windmill base; 12, well; 13, stone house.

buildings.—House very poor; stables fair; milk house very poor; privy poor, open vault and unprotected.

Milk.—Retailled in St. Paul; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 9. A good supply.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—Eighty acres.

Kind of farming.—Dairy.

Topography.—The house is about 3 feet above the well and about 12 feet above the stables. The general slope is away from the house in the direction of the well and outbuildings.

Source of water supply.—(See fig. 55.) Well about 20 feet from house; 57 feet in depth, 22 feet dug and 35 feet driven, dug part filled to about 10 feet of surface; casing, 1½-inch iron pipe. *Strata:* Clay, 50 feet, and sand, 7 feet. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables in bad location and receive little attention; milk house well cared for; privy poor, unprotected vault.

Milk.—Retailled in St. Paul; sanitary care good.

Source of water supply.—(See fig. 54.)

Well in combined pump and milk house; 119 feet in depth; casing, 2½-inch iron pipe. *Strata:* Sand, 25 feet; the remainder clay and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Well pit 7 feet deep, cased with wood. The mouth of well pit is quite well protected from surface wash. The well is too near the stables and privy, and during wet seasons it would seem almost impossible to prevent seepage into the well pit from these sources.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and out-

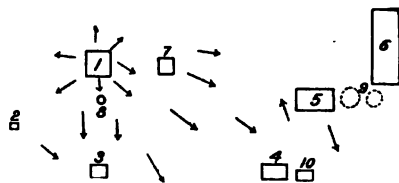


FIG. 55.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 9: 1, House; 2, privy; 3, outdoor kitchen; 4, tool and wagon shed; 5, horse barn; 6, cow stables; 7, milk house; 8, well; 9, silos; 10, tool shed.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 10. A good supply.

Location of farm.—Red Wing, Minn.

Date of visit.—July 23, 1908.

Size.—Seventy acres.

Kind of farming.—Dairy and general.

Topography.—The house is located on a level strip of ground sloping in three directions and is about 10 feet above the outbuildings.

Source of water supply.—(See fig. 56.) Well in milk room at back of house; 20 feet in depth; casing, 1½-inch iron pipe; well pit, 10 feet deep and 3 feet in diameter. *Strata:* Surface soil, 5 feet, and sand, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. The wash water and soluble wastes from the house are carried by a tile drain pipe to the edge of the marsh some 4 rods distant.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Hay Creek, a small creek near back of house.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.

Milk.—Sold in Red Wing; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

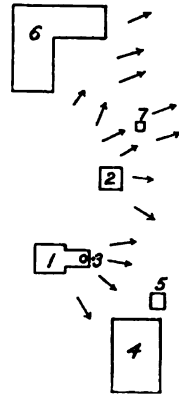


FIG. 56.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 10: 1, House; 2, ice house; 3, well; 4, stables; 5, milk house; 6, barn and stables; 7, privy.

No. 11. A good supply. This may, however, become polluted unless the well pit is kept clean and dry.

Location of farm.—Morris, Minn.

Date of visit.—August 10, 1908.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—The well is about 1½ feet above house and stables. The general slope is away from the well in all directions.

Source of water supply.—(See fig. 57.) Well about 25 feet from stables; 182 feet in depth; casing, 2½-inch iron pipe. *Strata:* Clay, 70 feet, and gravel and sand, 112 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. The well pit, which is 12 feet deep and cased with boards, is used as a storage reservoir and is constantly over half full of water. The water from the pit is used for cattle only. There is always danger of a filled pit leaking into the well through defective casing. The covering is of loose boards.

Cisterns.—One, under house, used for washing and at times for drinking, but owner stated that they never drank this water unless it had been boiled.

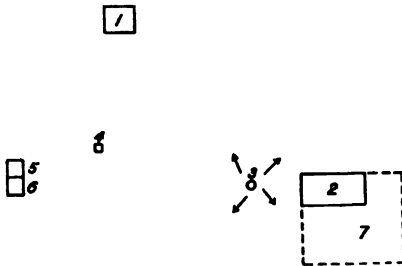


FIG. 57.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 11: 1, House; 2, barn and stables; 3, well; 4, privy; 5, ice house; 6, tool shed; 7, barnyard.

Lakes, rivers, ponds, and springs.—Two ponds which contain water all the year.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—One case of typhoid on this farm eighteen years previous to date of visit, but a different source of water supply was used at that time. No definite data could be obtained regarding the case.

Analyses.—See page 79.

No. 12. A good supply. This supply must be given exceptional care, especially against surface wash from the barnyard. The use of the well pit for refrigeration is inadvisable. It would be best to sink a well for domestic supply some distance from the barnyard and outbuildings.

Location of farm.—Henning, Minn.

Date of visit.—August 11, 1908.

Size.—One hundred and sixty acres.

Topography.—Perfectly level.

Source of water supply.—(See fig. 58.) Well 25 feet from house and 175 feet from stables at edge of barnyard; 24 feet in depth, 16 dug and 8 driven; casing, 2-inch

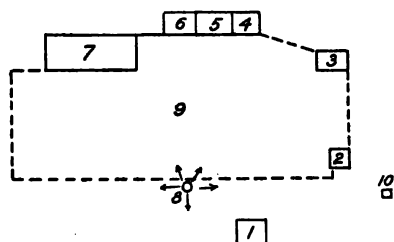


FIG. 58.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 12; 1, House; 2, tool shed; 3, granary; 4, hogpen; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, barnyard; 10, privy.

boards in dug portion and 2-inch iron pipe in driven portion. *Strata:* Clay, 8 feet, and sand, 16 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. As the number of animals cared for in the barnyard increases the well may become polluted. The covering is in poor condition; the planks are left loose so that they can be removed and pails of milk, etc., suspended in the well. On date of visit the dug portion contained several feet of water.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house excellent; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care good.

Water-borne diseases.—Two cases of typhoid fever have occurred on this farm; a girl, age 16, taken sick July 14, 1908, and a boy, age 14, taken sick July 25. The entire family, numbering seven persons, had attended two circuses a short time previous to the infection of the first case. The first circus attended was at Wadena, Minn., June 27, on which occasion all the family drank water from several sources in Wadena as well as on the train, and also drank circus lemonade. The second circus was at Henning, July 10; on this occasion both of the infected people drank water from several sources in Henning. Judging from the date of the first appearance of the infection, it would seem reasonable to think the disease was contracted at Wadena. The second case might have been infected from the original source, but more probably was infected from the first case.

Analyses.—See page 79.

No. 13. A polluted supply. This may be due to bad water used for priming, but is more probably due to a too rapid inflow from the river. Sinking a well at a greater distance from the river and installing a good pump would give a good supply.

Location of farm.—Crookston, Minn.

Date of visit.—September 11, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—Grain.

Topography.—Surface very broken; slope in direction of Red Lake River. Elevation of principal buildings about 25 feet above river.

Source of water supply.—(See fig. 59.) Well about 25 feet from Red Lake River, surface elevation about 20 feet above bed of river; 12 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sand, 4 feet; clay, 4 feet; and sand, 4 feet. *Yield:* Insufficient.

Use: Drinking and general farm purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. Far enough from buildings to be safe from such pollution and surface well protected except for priming the pump. This well may receive a direct flow from the river, as the water supply follows very closely its rise and fall.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River flows through farm and is used for drinking and other purposes.

Sanitary condition of farmhouse and outbuildings.—House good; stables very poor; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care fair.

Water-borne diseases.—Two cases of typhoid fever occurred on this farm in the spring of 1908, a girl 19 years old taken sick February 10, and a boy 13 years old taken sick March 10. The first patient had not been away from the farm for at least six weeks previous to the infection, as during the cold weather the people in this back country move about very little. The water used in the winter for drinking purposes is taken from the Red Lake River and no well water is used. The second patient had been around the neighborhood but not to any adjoining towns during the period of infection. The physician and family lay the source of infection to the river water, and judging from other cases in the same vicinity this is undoubtedly the source. The second case might be contact or from the original source, the river, for the family drank the river water until February 25.

Analyses.—See page 79.

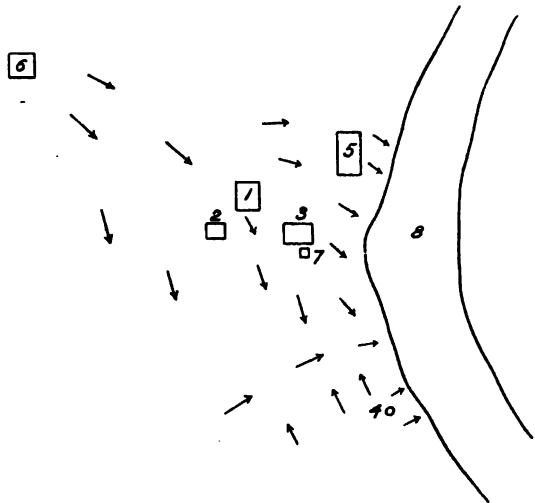


FIG. 59.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 13: 1, House; 2, granary; 3, hogpen; 4, well; 5, stables; 6, granary; 7, privy; 8, Red Lake River.

No. 14. A polluted supply. Thorough surface protection might make this a good supply. It would be better, however, to sink a well farther from the stable and barnyard.

Location of farm.—Crookston, Minn.

Date of visit.—September 11, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 60.) Well about 5 feet from stable; 25 feet in depth,

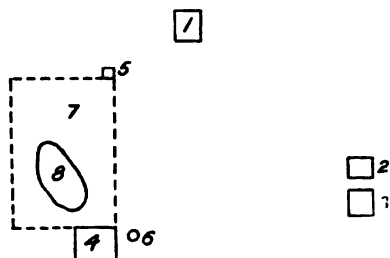


FIG. 60.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 14: 1, House; 2, granary; 3, granary; 4, stables; 5, privy; 6, well; 7, barnyard; 8, pond.

dug 20 feet and driven 5 feet; casing,

1½-inch pipe. *Strata:* Blue prairie clay.

Yield: Insufficient during dry season.

Use: Drinking and general farm purposes.

Method of lifting: Iron pump. *Sanitary*

aspect: Bad. The poor covering allows

surface wash to enter. The dug portion

contains several feet of water and gives

off a bad odor when cover is removed.

From the color of the pump water it is

evident that this offensive water from the

dug portion reaches the well proper.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One pond in barnyard.

Sanitary condition of farmhouse and outbuildings.—House very poor; stable very poor; privy very poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 15. A good supply.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The ground surrounding house and outbuildings is level with the exception of a slight incline near shore of lake. House is about 1½ feet above lake.

Source of water supply.—(See fig. 61.) Well 3 feet from house and 35 feet from lake; 65 feet in depth; casing, 1½-inch iron pipe; well pit, 10 feet deep, in good, dry condition. *Strata:* Unknown.

Yield: Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump.

Sanitary aspect: Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Round Lake, a small circular lake probably 40 rods at greatest width.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; privy, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

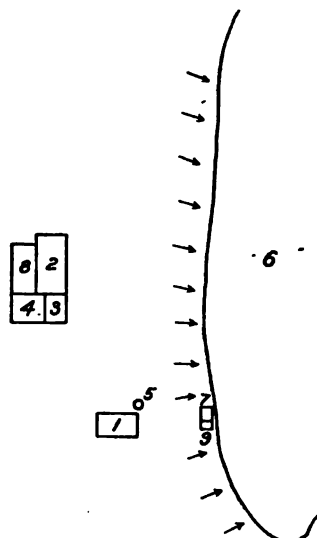


FIG. 61.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 15: 1, House; 2, stables; 3, stables; 4, wagon shed; 5, well; 6, Round Lake; 7, wood shed; 8, stable; 9, privy.

No. 16. A good supply. The location of this supply is too near the house and privy, yet the natural sand filter will keep it safe under the existing conditions. Improved surface protection is advisable, especially if the draft upon the well is increased.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—One hundred and eighty acres.

Kind of farming.—General.

Topography.—Level ground of a sandy surface character. Surface adjacent to house is artificially elevated about 1 foot above surrounding ground. Drainage in all directions away from house and well.

Source of water supply.—(See fig. 62.)

Well about 5 feet from house; 36 feet in depth, dug 28 feet and driven 8 feet; casing, dug portion bricked, driven portion 1½-inch iron pipe. *Strata:* Sand.

Yield: Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Privy 50 feet away on slightly lower ground. Back flow from pump enters dug portion of well. Covering in poor condition.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Round Lake touches one side of farm, and a small river, outlet to the lake, flows through part of farm.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy very poor, open vault and unprotected.

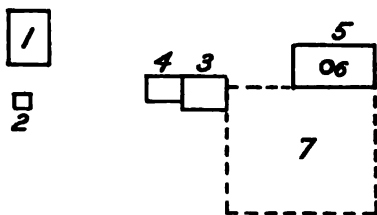


FIG. 63.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 17: 1, House; 2, privy; 3, granary; 4, wagon shed; 5, stables; 6, well; 7, barnyard.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—One hundred and forty-five acres.

Kind of farming.—General.

Topography.—Level prairie; surface soil sandy.

Source of water supply.—(See fig. 63.) Well in farm barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron cistern pump. *Sanitary aspect:* Bad. Well is located in stable directly between the horse and cow stalls, and the drainage from the dirt floor of the stables forms a puddle around the well pipe.

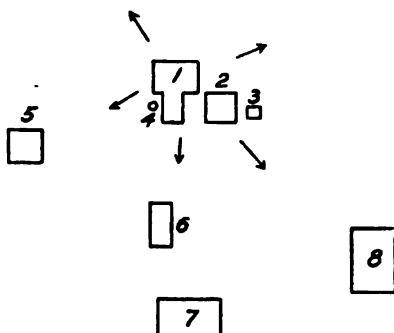


FIG. 62.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 16: 1, House; 2, ice house; 3, privy; 4, well; 5, wagon shed; 6, chicken coop; 7, hay barn; 8, stables.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 17. A good supply. The surroundings are very unsanitary, and although the natural filtration of the upper strata may protect the water indefinitely it would be advisable to sink a well in a better place for domestic use.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds, permanent throughout the year.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream shipped to St. Paul; sanitary care very poor.

Water-borne diseases.—One case of typhoid. The patient, a man 38 years old, was taken sick October 10, 1907, while repairing the public road near his house. Previous to his illness he drank water at several of the neighboring wells, though no other cases of typhoid developed in the neighborhood. On September 19, 20, and 21 the patient attended a street fair at Anoka and drank water from the city fountain several times. Several cases of typhoid were present in the city of Anoka and were supposed to have derived their infection from the city supply. The water supply of Anoka is taken from the Rum River, which has been found to be polluted.^a One of the State insane asylums is located a short distance above the city and turns its sewage into the river after partial purification.

Analyses.—See page 79.

No. 18. A good supply. This supply will eventually become polluted unless the mouth and well pit are given better protection against surface wash and drainage from the upper strata.

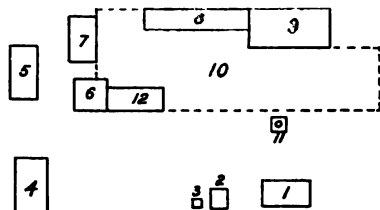


FIG. 64.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 18: 1, House; 2, wood shed; 3, privy; 4, tool shed; 5, tool shed; 6, granary; 7, hog-pen; 8, stables; 9, barn and stables; 10, barn-yard; 11, well; 12, tool shed.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred acres.

Kind of farming.—General.

Topography.—Level prairie; sandy surface.

Artificial drainage in several directions.

Source of water supply.—(See fig. 64.) Well in pump house; 28 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method*

of lifting: Iron pump. *Sanitary aspect:* Bad, located at edge of barnyard. Drinking tank for cattle about 5 feet from well and surrounded by mud. Well pit contains about 1 foot of water as back flow and surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream retailed in Anoka; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 19. A good supply. This supply is in danger of becoming polluted by seepage from the well pit. A good covering should be installed, and a drain ditch should lead off the water from the cattle trough.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

^a Determination made by Minnesota State Board of Health.

Size.—Thirty acres.

Kind of farming.—General.

Topography.—Level ground of a sandy surface type. Drainage in no special direction.

Source of water supply.—(See fig. 65.) Well about 40 feet from house; 25 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. Well about 30 feet from barnyard. Watering trough for cattle a few feet from well and surrounded by mud. Covering in very poor condition, so back flow from pump enters freely. Well pit contains several inches of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

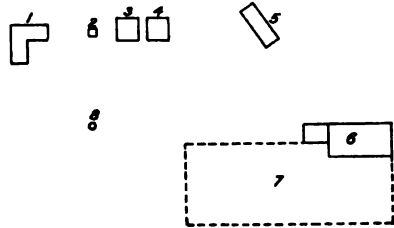


FIG. 65.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 19: 1, House; 2, privy; 3, tool shed; 4, cornerrib; 5, chicken house; 6, barn and stables; 7, barnyard; 8, well.

SPRINGS.

No. 1. A polluted supply. This supply could be made safe and attractive by proper protection against water from the surface and upper strata. The privy should be moved to a greater distance and preferably to a lower level.

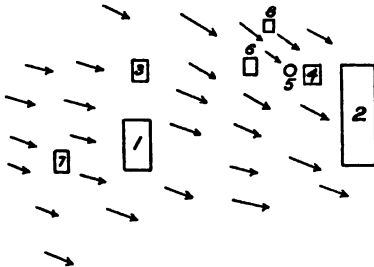


FIG. 66.—Sketch showing the topography and the location of buildings in the vicinity of spring No. 1: 1, House; 2, barn and stables; 3, wood shed; 4, milk house; 5, spring; 6, tool shed; 7, outdoor kitchen; 8, privy.

Unfortunately, however, the privy is only about 20 feet away and the spring is poorly protected.

Cisterns.—None.

Lakes, rivers, ponds, and wells.—None.

Sanitary condition of farmhouse and outbuildings.—House good; outbuildings fair; privy poor, unprotected vault.

Milk.—Retailled in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-five acres.

Kind of farming.—Dairy.

Topography.—The surface slopes from house and outbuildings toward the barn; a difference in elevation of about 8 feet. The land on the opposite side of the barn from the house is low and marshy.

Source of water supply.—(See fig. 66.) Spring on sloping ground surrounded by outbuildings; dug down about 10 feet and cased with wood. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Sanitary aspect:* Bad. The spring is so located that with care good water could be secured;

No. 2. For a description of this spring, see cistern No. 3, under the heading "Lakes, rivers, ponds, and springs," page 66.

RIVERS.

No. 1. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a dug well, although the river water has been used during the winter season. For description, see No. 26, under the heading "Dug wells."

No. 2. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

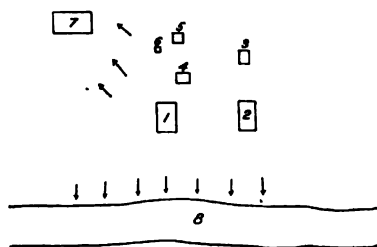


FIG. 67.—Sketch showing the topography and the location of buildings in the vicinity of river No. 2: 1, House; 2, blacksmith shop; 3, chicken house; 4, wood shed; 5, chicken house; 6, privy; 7, stable; 8, Red Lake River.

Location of farm.—Huot, Minn.

Date of visit.—September 11, 1908.

Size.—One acre.

Kind of farming.—General.

Topography.—Drainage from the farm buildings is chiefly away from the river.

Source of water supply.—(See fig. 67.) Well; see report No. 26 under "Dug wells" for description of well which was also used by this family.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River forms the southern boundary of the property and served as a water supply

during the winter until typhoid fever developed.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor. privy very poor, open vault entirely unprotected.

Milk.—Used on farm; sanitary care very poor.

Water-borne diseases.—Three cases of typhoid fever occurred on this place during February, March, and April, 1908. The first, a boy 10 years old, was taken sick about February 15; the second, a man 40 years old, February 28, and the third, a boy 7 years old, April 19. All of these people drank river water from the Red Lake River from September 30 until March 15, on which date the doctor in charge decided the river water to be the source of infection.

Analyses.—See page 79.

No. 3. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

Location of farm.—Thief River Falls, Minn.

Date of visit.—September 14, 1908.

Size.—Seventy-seven acres.

Kind of farming.—General.

Topography.—House and outbuildings 20 feet above Red Lake River. Entire drainage from yards is in direction of river.

Source of water supply.—(See fig. 68.) Red Lake River.

Cisterns.—None.

Lakes, wells, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, open vault and unprotected. This is a typical pioneer residence. The property was formerly part of the Red Lake Indian Reservation and has recently been taken up by settlers.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 4. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a driven well, although the river water has been used during the winter season. For description, see No. 13, under the heading "Driven wells."

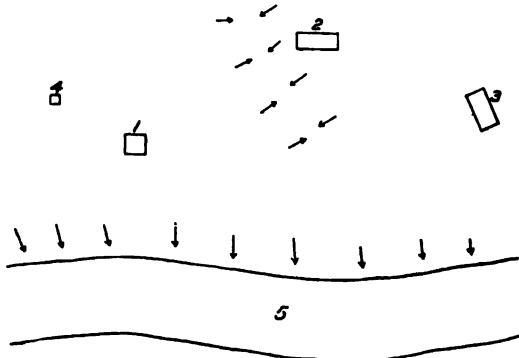


FIG. 68.—Sketch showing the topography and the location of buildings in the vicinity of river No. 3: 1, House; 2, chicken house; 3, stables; 4, privy; 5, Red Lake River.

SURFACE RESERVOIRS.

No. 1. For a description of this reservoir, see cistern No. 1, under the heading "Lakes, rivers, ponds, and springs," p. 64.

No. 2. For a description of this reservoir, see cistern No. 2, under the heading "Lakes, rivers, ponds, and springs," p. 65.

CISTERNs.

No. 1. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

^a Moore, G. T., and Kellerman, K. F. *Methods of Destroying or Preventing the Growth of Algae and Certain Pathogenic Bacteria in Water Supplies.* Bureau of Plant Industry, Bul. 64. 1904.

Kraemer, Henry. *The Copper Treatment of Water.* *American Journal of Pharmacy*, vol. 76, No. 12, pp. 574-579. 1904.

Lewis, Frank C. *The Sterilization of Water.* *Public Health Engineering*, vol. 16, No. 415, p. 350. London, 1905.

Maignen, P. A. *Different Methods of Purifying Water.* *Proceedings of the Engineers' Club of Philadelphia*, vol. 24, No. 1, pp. 1-69. 1907.

Location of farm.—Kennedy, Minn.

Date of visit.—September 15, 1908.

Size.—Twelve thousand acres.

Kind of farming.—General and grain.

Topography.—Farm buildings located on level prairie land.

Source of water supply.—(See fig. 69.) Cistern under farmhouse kitchen. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* Two hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. There are two openings, a circular manhole at the top and a small 4-inch opening in the side near the roof. The manhole is well protected with a tight board cover. A small well-protected pipe for carrying water into the cistern leads to the opening in the side, which pipe affords the only means of ventilation. An odor was complained of which could possibly be eliminated by better ventilation.

Lakes, rivers, ponds, and springs.—A second source of water supply for this farm is a shallow surface reservoir. This reservoir was scooped out of the surface soil and

allowed to fill with surface water during the spring season, and it constitutes a supply for general farm use. It is about 60 feet long and 40 feet wide. The water is partly filtered by being passed to a well pit through a ditch dug in the clay and filled with gravel; however, this improves the condition of the water very little. The water is pumped from the well pit. The sanitary aspect is very bad; the water is entirely unprotected and is grossly polluted. On the date of visit it contained a large quantity of vegetable growth.

Sanitary condition of farmhouse and out-buildings.—House good; stables very

good; privy good, open vault well protected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 2. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Kennedy, Minn.

Date of visit.—September 15, 1908.

Size.—One thousand acres.

Kind of farming.—General and grain.

Topography.—Level prairie land.

Source of water supply.—(See fig. 70.) Cistern under kitchen of farmhouse. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* One hundred and fifty barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect.* Fair. Surface in good condition and opening for entrance of water well protected.

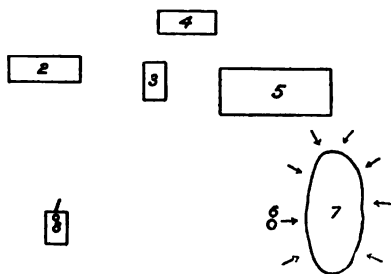


FIG. 60.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 1: 1, House; 2, granary; 3, wagon shed; 4, feed house; 5, barn and stables; 6, well pit; 7, reservoir; 8, cistern.

Lakes, rivers, ponds, and springs.—A surface reservoir is used for an additional supply for cattle, and in case of necessity for drinking. It is dug in clay soil, and its approximate dimensions are 60 feet long, 35 feet wide, and 6 feet deep. It is allowed to fill with surface water during the winter and spring, and the heavy clay soil holds the water throughout the summer. The sanitary conditions surrounding this supply are very bad. Surface wash from the barnyard enters freely; decaying vegetable growths could be seen in water on date of visit. The water is pumped directly from the reservoir by means of a wooden pump suspended on a platform built over the water. These surface water supplies are necessarily used on account of the impracticability of a deep ground supply or of a surface well. The deep ground waters of this area are very salty and in most cases have a strong alkaline taste, which renders them impossible for domestic or farm use.

Sanitary condition of farmhouse and outbuildings.—House very good; stables very good; privy good, open vault well protected.

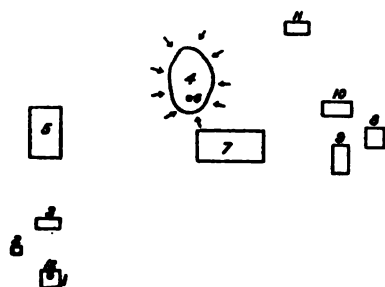


FIG. 70.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 2: 1, House; 2, privy; 3, wood shed; 4, reservoir; 5, tool shed; 6, pump; 7, barn and stables; 8, granary; 9, chicken coop; 10, granary; 11, hogpen; 12, cistern.

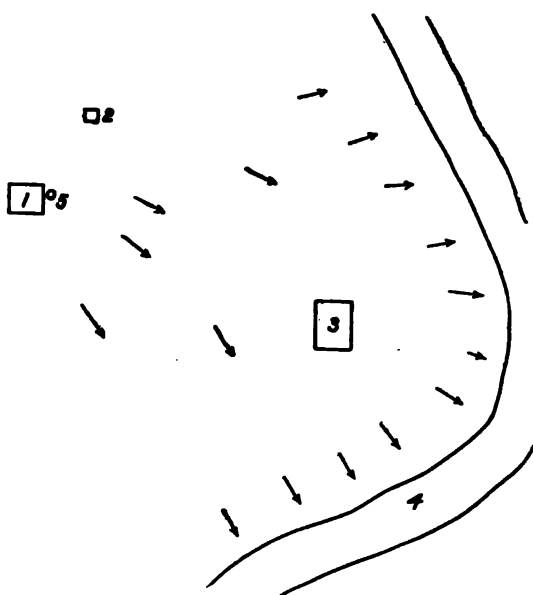


FIG. 71.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 3: 1, House; 2, privy; 3, stables; 4, creek; 5, cistern.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—Surface undulating; buildings on banks of creek; house about 5 feet higher than barn, 30 feet higher than creek.

Milk.—Used by family; sanitary care very good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 3. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Source of water supply.—(See fig. 71.) Cistern at side of house. *Type:* Dug, with galvanized iron casing; circular, with flat top. *Capacity:* Sixty barrels. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Cistern appears to be well protected in every way; surface of galvanized tank tightly covered with boards; top projects some few feet above surface of ground and thus eliminates all danger of surface water entering.

Lakes, rivers, ponds, and springs.—An interesting feature on this farm is a salt spring. It is very troublesome, as it flows into a small creek near the farm buildings and completely ruins the water for all farm purposes. The flow is probably no more than several barrels an hour, but even this small quantity is sufficient to impart a bad taste to the creek water. This spring water is quite similar in taste and appearance to the water in the few wells in that vicinity. A sample was collected for the purpose of studying the character of these disagreeable ground waters of the Red River Valley district.

Sanitary condition of farm-house and outbuildings.—House good; stables fair; privy poor, open vault entirely unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

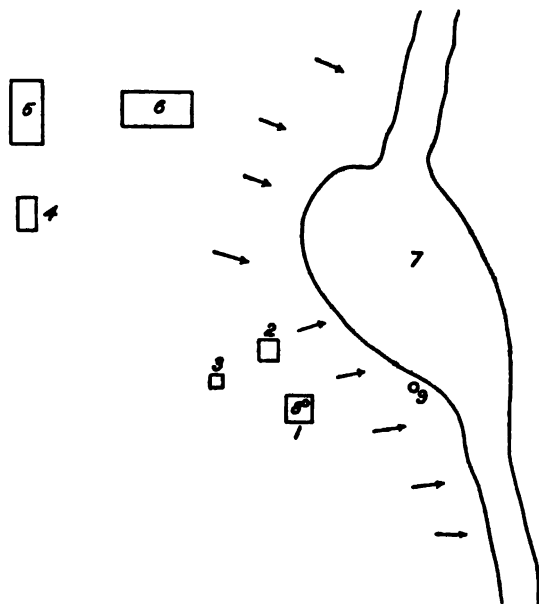


FIG. 72.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 4: 1, House; 2, ice house; 3, privy; 4, tool shed; 5, stables; 6 granary; 7, creek; 8, cistern; 9, well.

No. 4. This is a badly polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—Grain.

Topography.—Drainage from the farm buildings flows in the direction of the creek.

Source of water supply.—(See fig. 72.) Two cisterns in cellar of house. *Type:* Galvanized iron tanks; circular, with flat bottoms. *Capacity:* One hundred barrels each. *Use:* Drinking and general house purposes. *Method of lifting:* Water dipped from tanks with pails. *Sanitary aspect:* Poor. The tanks were in excellent condition, but lacked coverings to protect them from dust and such other material as might fall from the floor above. The tin pipe leading from roof to tanks is provided with a sort of filter, consisting of a rectangular tin box 12 inches by 5 inches by 5 inches,

with a conical bottom. Bags of charcoal the proper size to fit this box are placed in it, and the water in flowing to the tanks must necessarily pass through this filter. The bags are removed after each rain and replaced by clean bags of the same material.

Lakes, rivers, ponds, and springs.—One creek.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. The cistern needs a thorough cleaning. With proper covering the condition of the cistern could be improved, and by wasting the first rinsing from the roof at the beginning of each rain the water might be kept in good condition.

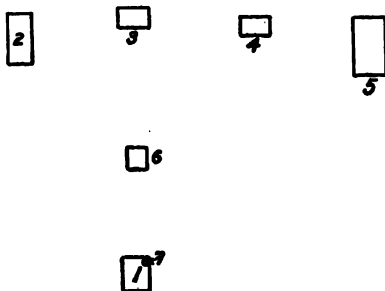


FIG. 73.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 5: 1, House; 2, granary; 3, tool shed; 4, hogpen; 5, stables; 6, wood shed and privy; 7, cistern.

Location of farm.—Hallock, Minn.

Date of visit.—September 17, 1908.

Size.—Four hundred and eighty acres.

Kind of farming.—Grain.

Topography.—Level prairie land.

Source of water supply.—(See fig. 73.) Cistern under kitchen. *Type:* Dug, with brick casing lined with cement; round, with conical roof. *Capacity:* One hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The covering is in very poor condition and the water has a strong odor of decaying organic matter.

Lakes, rivers, ponds, and springs.—Several ponds have been dug to collect water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables good; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

TABULATION OF SANITARY SURVEYS.

The following tables give full information in regard to the sanitary surveys, including analyses:

TABLE I.—Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made.

DUG WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	<i>Acres.</i>			
1	Merriam Park.....	July 3	80	General.....	Rolling.....	Fair.
2	Minneapolis.....	July 8	36	Dairy.....	Level.....	Poor.
3	St. Paul.....	July 16	12	do.....	Undulating.....	Good.
4	do.....	do.	140	General.....	do.....	Do.
5	do.....	July 17	160	do.....	Irregular.....	Fair.
6	Gladstone.....	July 20	13	do.....	do.....	Good.
7	do.....	July 18	75	Dairy.....	Rolling.....	Do.
8	Hastings.....	July 22	120	General.....	do.....	Poor.
9	do.....	do.	40	Dairy.....	Level.....	Fair.
10	Red Wing.....	July 23	103½	do.....	Rolling.....	Poor.
11	do.....	July 24	3	General.....	Irregular.....	Do.
12	Mankato.....	July 28	120	Dairy.....	Level.....	Do.
13	do.....	do.	28	do.....	do.....	Do.
14	do.....	do.	65	do.....	do.....	Do.
15	Owatonna.....	July 30	200	do.....	do.....	Good.
16	do.....	do.	136	General.....	Rolling.....	Poor.
17	Austin.....	Aug. 1	640	do.....	Level.....	Do.
18	do.....	do.	80	do.....	do.....	Fair.
19	Oakland.....	do.	70	do.....	do.....	Poor.
20	do.....	do.	235	do.....	do.....	Do.
21	Rochester.....	Aug. 4	160	do.....	Rolling.....	Good.
22	South Haven.....	Aug. 14	150	do.....	Irregular.....	Do.
23	St. Cloud.....	do.	248	do.....	Level.....	Poor.
24	Sauk Center.....	Aug. 17	160	Grain.....	do.....	Do.
25	Crookston.....	Sept. 10	160	do.....	do.....	Do.
26	Huot.....	Sept. 11	2	General.....	Irregular.....	Fair.
27	Thief River Falls.....	Sept. 14	145	Grain.....	Level.....	Poor.
28	Hallock.....	Sept. 16	320	General.....	do.....	Fair.

BORED WELLS.

1	Chiklo.....	Aug. 10	160	General.....	Level.....	Poor.
2	Sauk Center.....	Aug. 17	120	do.....	do.....	Do.
3	Argyle.....	Sept. 12	160	Grain.....	do.....	Fair.
4	do.....	do.	160	do.....	do.....	Do.

DRILLED WELLS.

1	Red Wing.....	July 24	18	Dairy.....	Irregular.....	Good.
2	St. Peter.....	July 27	120	General.....	Level.....	Poor.
3	Owatonna.....	July 30	160	do.....	do.....	Fair.
4	do.....	do.	240	do.....	Rolling.....	Good.
5	Rochester.....	Aug. 4	185	do.....	do.....	Fair.
6	Alexandria.....	Aug. 12	141	do.....	Irregular.....	Do.
7	do.....	do.	220	do.....	do.....	Good.
8	Sauk Center.....	Aug. 17	330	do.....	Rolling.....	Do.
9	Crookston.....	Sept. 10	240	Grain.....	Level.....	Poor.
10	do.....	do.	320	do.....	do.....	Do.
11	do.....	do.	160	do.....	do.....	Do.
12	Hallock.....	Sept. 17	480	do.....	do.....	Do.
13	Anoka.....	Sept. 29	230	General.....	do.....	Fair.

TABLE I.—Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made—Continued.

DRIVEN WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	Acres.			
1	Excelsior.....	June 30	140	General.....	Irregular.....	Good.
2	New Brighton.....	July 3	40	do.....	Rolling.....	Fair.
3	St. Louis Park.....	July 6	60	Dairy.....	Irregular.....	Poor.
4	Minneapolis.....	July 8	180	do.....	Undulating.....	Do.
5	Richfield.....	July 10	90	do.....	Rolling.....	Do.
6	Minneapolis.....	do	230	General.....	Level.....	Do.
7	St. Paul.....	July 15	3	Dairy.....	do.....	Do.
8	do.....	do	10	do.....	Irregular.....	Do.
9	do.....	July 17	80	do.....	Undulating.....	Fair.
10	Red Wing.....	July 23	70	do.....	do.....	Do.
11	Morris.....	Aug. 10	240	General.....	Level.....	Do.
12	Hennepin.....	Aug. 11	160	do.....	do.....	Poor.
13	Crookston.....	Sept. 11	320	Grain.....	Irregular.....	Good.
14	do.....	do	160	do.....	Level.....	Poor.
15	Gladstone.....	July 20	40	General.....	do.....	Good.
16	Anoka.....	Sept. 29	180	do.....	do.....	Do.
17	do.....	do	145	do.....	do.....	Poor.
18	do.....	do	200	do.....	do.....	Fair.
19	do.....	do	30	do.....	do.....	Poor.

SPRINGS.

1	Minneapolis.....	July 8	35	Dairy.....	Irregular.....	Poor.
2	Hallock.....	Sept. 16	240	General.....	Undulating.....	Good.

RIVERS.

1	Huot.....	Sept. 11	2	General.....	Irregular.....	Fair.
2	do.....	do	1	do.....	do.....	Do.
3	Thief River Falls.....	Sept. 14	77	do.....	Level.....	Do.
4	Crookston.....	Sept. 11	320	Grain.....	Irregular.....	Do.

SURFACE RESERVOIRS.

1	Kennedy.....	Sept. 15	12,000	Grain.....	Level.....	Fair.
2	do.....	do	1,000	do.....	do.....	Do.

CISTERNS.

1	Kennedy.....	Sept. 15	12,000	Grain.....	Level.....	Fair.
2	do.....	do	1,000	do.....	do.....	Do.
3	Hallock.....	Sept. 16	240	General.....	Undulating.....	Good.
4	do.....	do	640	Grain.....	Irregular.....	Do.
5	do.....	Sept. 17	480	do.....	Level.....	Poor.

TABLE II.—Local and structural details concerning the water supplies in Minnesota of which an investigation was made.

DUG WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Yield.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
1	Poor....	<i>Fed.</i> 28	Clay, 23 feet; sand, 5 feet....	Brick....	Insufficient....	Drinking and general farm purposes.	Iron pump....	Hand....	Cistern.
2	do....	15	Soft marsh soil....	Wood....	Abundant....	do....	do....	do....	Ponds.
3	Good....	80	Unknown....	do....	do....	do....	do....	Windmill.	None.
4	Poor....	38	Clay, 28 feet; sandy gravel, 10 feet....	do....	Insufficient....	do....	Rope and bucket....	Hand....	Ponds.
5	do....	25	Clay....	Tile, 12-inch....	Abundant....	do....	Wooden pump....	do....	Cistern.
6	Fair....	22	Clay, 9 feet; sand, 13 feet....	Wood....	do....	do....	Rope and bucket....	do....	Lake, creek.
7	do....	20	Gravel and clay....	do....	do....	do....	Iron pump....	Windmill.	Ponds.
8	Poor....	18	Gravel....	Stone....	do....	do....	do....	Hand....	Cistern.
9	Good....	127	Sand and gravel mixed....	Tile, 6-inch....	do....	do....	do....	Windmill.	do.
10	Poor....	15	Black marsh soil....	Stone....	do....	do....	Rope and bucket....	Hand....	Creek, springs.
11	do....	10	Surface soil and sand....	do....	do....	do....	Iron pump....	do....	None.
12	do....	25	Sand, clay, and gravel mixed....	Stone....	do....	do....	do....	do....	Springs, ponds, cistern.
13	do....	12	Clay, 8 feet; gravel, 4 feet....	do....	Insufficient....	do....	do....	do....	Ponds.
14	do....	27	Surface soil and blue clay....	do....	do....	do....	do....	do....	Cistern, ponds.
15	do....	40	Blue clay....	do....	Abundant....	do....	do....	do....	Cistern.
16	do....	30	Unknown....	do....	do....	do....	do....	Windmill.	do.
17	do....	60	Yellow clay....	Tile....	do....	do....	do....	do....	do.
18	Good....	28	Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet; rock, 8 feet....	Wood....	do....	do....	do....	Hand....	None.
19	Poor....	12	Gravel, blue clay, quicksand....	Tile, 2-foot....	do....	do....	Wooden pump....	do....	do.
20	do....	30	Surface soil, 3 feet; rest clay....	Stone....	do....	do....	Iron pump....	do....	do.
21	Fair....	30	Surface soil, 3 feet; clay, 10 feet; gravel 17 feet....	do....	do....	do....	do....	do....	Cistern.
22	Poor....	14	Clay, 13 feet; gravel and sand, 1 foot....	Wood....	do....	do....	do....	do....	Pond.
23	Fair....	44	Hardpan, clay, gravel, sand....	Brick....	do....	do....	do....	do....	None.
24	do....	25	Clay and sand....	Wood....	do....	do....	Wooden pump....	do....	do.
25	do....	40	Blue clay....	do....	do....	do....	do....	do....	do.
26	Poor....	12	Sand, gravel, and clay....	do....	do....	do....	Iron pump....	do....	River.
27	Fair....	13	Blue clay....	do....	do....	do....	Rope and bucket....	do....	None.
28	Good....	18	Loam, 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet....	Brick and wood....	Insufficient....	do....	do....	do....	River.

BORED WELLS.

1	Poor.....	55	Clay 40 feet; sand and gravel, 15 feet.	Wood.....	Abundant.....	Drinking and general farm purposes.	Iron pump.....	Hand.....	None.
2	do.....	27	Clay and sand.....	None.....	do.....	do.....	Wood pump.....	do.....	Do.
3	Fair.....	10	Blue prairie clay.....	Tin, 6-inch.....	Insufficient.....	Drinking.....	Rope and bucket.....	do.....	River.
4	do.....	13	do.....	do.....	Abundant.....	do.....	do.....	do.....	None.

DRILLED WELLS.

No.	Char-acter of loca-tion.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
1	Poor..	138	Feet. Clay, 17 feet; rest limestone.	Iron pipe, 6-inch, and rock.	Feet. 25	Stone.	Abundant.....	Drinking and general farm purposes.	Iron pump.....	Horse.....	Cisterna.
2	do..	167	Clay and sand.....	Iron, 2-inch.	40	do.	do.....	do.....	do.....	Windmill.	Do.
3	Good..	100	Blue clay and rock.....	Iron pipe, 6-inch.	10	Wood.	do.....	do.....	do.....	Hand.....	Well, cistern.
4	Poor..	90	Clay 40 feet; rest gravel, sand and gravel, 10 feet.	do.....	30	Stone.	do.....	do.....	do.....	Windmill.	Cistern.
5	do..	60	Sand and clay, 30 feet; limestone, 30 feet.	Iron pipe, 3-inch.	do.	do.	do.....	do.....	do.....	do.	Do.
6	Good..	80	Clay and sand.....	do.....	do.	do.	do.....	do.....	do.....	Hand.....	Lake, creek, spring.
7	Poor..	60	Clay and gravel, 10 feet.	Iron, 4-inch.	10	Wood.	do.....	do.....	do.....	do.	Cistern, ponds.
8	Good..	153	Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet.	Iron, 2-inch.	14	Iron, 24 feet.	do.....	do.....	do.....	Windmill.	None.
9	do..	200	Blue clay throughout.....	do.....	do.	do.	do.....	do.....	do.....	do.	Cistern.
10	do..	180	Unknown.....	do.....	do.	do.	do.....	do.....	do.....	Hand.....	None.
11	Fair..	203	Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; sand, 3 feet.	Iron, 24-inch.	do.	do.	do.....	do.....	do.....	do.	Cistern.
12	Poor..	75	Hardpan and clay mixture.....	do.....	10	Wood.	Insufficient.....	do.....	do.....	Windmill.	Ponds, cistern.
13	Good..	112	Sand and gravel.....	Iron, 3-inch.	do.	do.	Abundant.....	do.....	do.....	Gasoline engine.	None.

TABLE II.—Local and structural details concerning the watersupplies in Minnesota of which an investigation was made—Continued.

DRIVEN WELLS.

No.	Char-acter of loca-tion.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
1	Good.	150	Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet.	Iron, 3-inch.	Feet. 6	Brick.	Abundant.	Drinking and general farm purposes.	Iron pump.	Gasoline engine and windmill.	Lake, creek, springs, and cistern.
2	Fair.	160	Unknown.	Iron pipe, 2-inch.	10	Wood.	do.	do.	do.	Windmill.	Cistern.
3	Poor.	60	do.	do.	10	do.	do.	do.	do.	do.	Ponds.
4	do.	20	Surface, 3 feet; sand, 17 feet.	do.	10	do.	do.	do.	do.	do.	None.
5	do.	50	Unknown.	Iron, 1½-inch.	10	do.	do.	do.	do.	Gasoline engine.	Cistern, lake.
6	do.	40	Sandy soil.	do.	10	do.	do.	do.	do.	Windmill.	Do.
7	do.	30	Unknown.	do.	8	do.	do.	do.	do.	do.	None.
8	do.	119	Sand, 25 feet; rest clay and gravel.	Iron, 2½-inch.	7	do.	do.	do.	do.	Hand.	Do.
9	Good.	57	Clay, 50 feet; sand, 7 feet.	Iron, 1½-inch.	10	do.	do.	do.	do.	Windmill.	Do.
10	Fair.	20	Surface soil, 5 feet; sand, 15 feet.	Iron, 1½-inch.	10	do.	do.	do.	do.	Hand.	Creek.
11	Good.	182	Clay, 70 feet; gravel and sand, 112 feet.	Iron, 2½-inch.	12	do.	do.	do.	do.	Windmill.	Cistern, ponds.
12	Poor.	24	Clay, 8 feet; sand, 16 feet.	Iron, 2-inch.	16	do.	do.	do.	do.	do.	Cistern.
13	Good.	12	Sand, 4 feet; clay, 4 feet; sand, 4 feet.	Iron, 1½-inch.	do.	do.	Insufficient.	do.	Cistern pump.	Hand.	River.
14	Poor.	25	Blue prairie clay.	do.	20	Wood.	do.	do.	Iron pump.	do.	Pond.
15	Fair.	65	Unknown.	do.	10	do.	Abundant.	do.	do.	do.	Lake.
16	do.	36	Sand.	Iron, 1½-inch.	28	Brick.	do.	do.	do.	do.	River, lake.
17	Poor.	40	do.	do.	do.	do.	do.	do.	Cistern pump.	do.	Ponds.
18	do.	28	Sand and gravel.	do.	10	Wood.	do.	do.	Iron pump.	do.	None.
19	Good.	26	do.	do.	10	do.	do.	do.	do.	Windmill.	Do.

SPRINGS.

No.	Character of location.	Character of surface around spring.	Spring pit.		Yield.	Use.	Means of lifting.		Other water on farm.
			Depth.	Casing.			Method.	Power.	
1	Poor.....	Gravelly soil.....	<i>Fet.</i> 10	Wood.....	Abundant.....	Drinking and general farm purposes. (Undrinkable).....	Bucket.....	Hand.....	None.
2	do.....	Marshy soil.....	1	None.....	do.....	do.....	do.....	do.....	Cistern, creek.

RIVERS.

No.	Locality.	Source.	Character of watershed.	Cities or villages on river above this farm.	Use.	Means of lifting.		Other water on farm.
						Method.	Power.	
1	Huot.....	Red Lake River.....	Large, flat area.....	About 6.....	Drinking and general farm purposes. do.....	Bucket.....	Hand.....	Well.
2	do.....	do.....	do.....	do.....	do.....	do.....	do.....	None.
3	Thief River Falls.....	do.....	do.....	About 4.....	do.....	do.....	do.....	Do.
4	Crookston.....	do.....	do.....	About 7.....	do.....	do.....	do.....	Well.

SURFACE RESERVOIRS.

No.	Character of location.	Type.	Source of water.	Shape.	Size.	Casing.	Use.	Means of lifting.		Other water on farm.
								Method.	Power.	
1	Poor.....	Dug.....	Rain.....	Oval.....	<i>Fet.</i> 60 by 40 by 6.....	Clay.....	General farm purposes.....	Iron pump.....	Windmill.....	Cistern.
2	do.....	do.....	do.....	Rectangular.....	60 by 35 by 6.....	do.....	do.....	Wooden pump.....	Hand.....	Do.

TABLE II.—*Local and structural details concerning the water supplies in Minnesota of which an investigation was made—Continued.*

CISTERNS.

No.	Character of location.	Type.	Capacity.	Shape.	Casing.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
1	Fair.....	Dug.....	<i>Barrels.</i> 200	Circular, arched top...	Brick and cement.....	Drinking and general farm purposes.	Cistern pump...	Hand.....	Surface reservoir.
2	do.....	do.....	150	do.....	do.....	do.....	do.....	do.....	Do.
3	Good.....	do.....	50	Circular, flat top...	Galvanized iron.....	do.....	do.....	do.....	Spring and creek.
4	Fair.....	Tanks.....	200	do.....	do.....	do.....	Fall and rope.....	do.....	Creek.
5	Poor.....	Dug.....	100	Circular, conical roof...	Brick and cement.....	do.....	Cistern pump.....	do.....	Ponds.

TABLE III.—Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made.

DUG WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.	
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.
1	Poor.	Fair.		Poor.	Unprotected vault.	Poor.	Used on farm.	None.	
2	do.	do.		do.	do.	do.	Sold.	do.	
3	do.	do.		Fair.	do.	do.	do.	Typhoid.	1
4	do.	Poor.		Poor.	do.	do.	Used on farm.	None.	
5	Fair.	Good.		Good.	do.	Good.	do.	do.	
6	Poor.	Poor.		Poor.	do.	No milk.	Sold.	Typhoid.	1
7	Fair.	Good.	Fair.	do.	Protected vault.	Fair.	Cream sold.	None.	Unknown.
8	do.	do.	Good.	do.	do.	Good.	Sold.	do.	
9	do.	do.	do.	do.	do.	do.	do.	do.	
10	Poor.	Good.	Poor.	Poor.	Unprotected vault.	Poor.	do.	do.	
11	do.	do.	do.	Good.	do.	Fair.	Used on farm.	do.	
12	do.	do.	Good.	do.	do.	Good.	Sold.	Typhoid.	1
13	do.	Fair.	Good.	Poor.	do.	Poor.	do.	None.	
14	Good.	Good.	Good.	Good.	Protected vault.	Good.	do.	do.	
15	Fair.	do.		do.	Unprotected vault.	do.	Sold to creamery.	do.	
16	Poor.	Poor.		Poor.	do.	Poor.	do.	do.	
17	do.	Good.	Fair.	Good.	do.	Good.	do.	do.	
18	Fair.	do.		Poor.	do.	Poor.	Butter sold.	do.	
19	Poor.	do.		Poor.	do.	do.	Sold.	Typhoid.	1
20	do.	Fair.		Good.	do.	Good.	do.	None.	
21	Good.	Good.		do.	Protected vault.	do.	do.	do.	
22	Poor.	Poor.		Poor.	Unprotected vault.	Poor.	Butter sold.	Typhoid.	1
23	do.	do.		do.	do.	do.	do.	do.	1
24	do.	do.		do.	do.	do.	Sold.	do.	1
25	do.	do.		do.	do.	do.	do.	do.	
26	do.	Good.		Fair.	do.	No milk.	do.	None.	
27	Poor.	do.		Poor.	do.	Poor.	Butter sold.	Typhoid.	1
28	do.	do.		do.	do.	do.	do.	None.	
								Red Lake River.	

BORED WELLS.

1	Fair.	Fair.		Good.	Unprotected vault.	Fair.	Sold.	Typhoid.	1
2	Poor.	Poor.		Poor.	do.	Poor.	do.	None.	
3	do.	Very poor.		Very poor.	do.	do.	Used on farm.	Typhoid.	6
4	do.	do.		Good.	do.	do.	do.	None.	
								Village of Oslo, Minn.	

TABLE III.—Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made—Continued.

DRILLED WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Fair.....	Fair.....		Poor.....	Unprotected vault.....	Poor.....	Sold.....	None.....	3	Unknown.
2	Poor.....	Good.....		Fair.....	do.....	Fair.....	do.....	Typhoid.....	1	Probably from neighbor.
3	Fair.....	Fair.....		do.....	do.....	do.....	do.....	do.....	1	Unknown.
4	Poor.....	Poor.....		Good.....	do.....	do.....	do.....	do.....		
5	do.....	do.....		Poor.....	do.....	Poor.....	do.....	None.....		
6	Fair.....	Fair.....		Fair.....	do.....	do.....	do.....	do.....		
7	Poor.....	Poor.....		do.....	do.....	do.....	do.....	do.....		
8	Good.....	Good.....		do.....	do.....	Good.....	do.....	None.....	8	Do.
9	do.....	do.....		do.....	do.....	Fair.....	do.....	Typhoid.....		
10	Poor.....	Poor.....		do.....	do.....	Poor.....	Butter sold.....	Typhoid.....	2	Do.
11	Fair.....	do.....		do.....	do.....	Fair.....	do.....	None.....		
12	do.....	do.....		do.....	do.....	Poor.....	do.....	do.....		
13	Good.....	Good.....	Good.....	do.....	Protected vault.....	Good.....	Cream sold.....	do.....		

DRIVEN WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
		House.	Milk house.	Stables.	Privy.					
1	Good.....	Good.....		Good.....	Modern.....	Good.....	Used on farm.....	None.....		
2	Fair.....	Fair.....		Poor.....	Unprotected vault.....	Poor.....	do.....	do.....		
3	Poor.....	Poor.....	Poor.....	do.....	do.....	do.....	Sold.....	do.....		
4	do.....	do.....	do.....	Fair.....	do.....	Fair.....	do.....	do.....		
5	do.....	Fair.....	do.....	do.....	do.....	do.....	do.....	do.....		
6	Good.....	Good.....		Good.....	Protected vault.....	Good.....	Used on farm.....	None.....	3	City of Minneapolis.
7	Poor.....	Poor.....	Fair.....	Fair.....	Unprotected vault.....	Fair.....	Sold.....	do.....		
8	Fair.....	do.....	Poor.....	do.....	do.....	Poor.....	do.....	do.....		
9	Good.....	Good.....	Good.....	Poor.....	do.....	Good.....	do.....	do.....		
10	do.....	do.....	do.....	do.....	do.....	do.....	do.....	do.....		
11	Fair.....	do.....	do.....	Good.....	do.....	do.....	Butter sold.....	Typhoid.....	1	Unknown.
12	do.....	do.....	Good.....	do.....	do.....	do.....	Cream sold.....	do.....	2	Circus at Wadena, Minn.
13	do.....	do.....	do.....	Poor.....	do.....	Fair.....	Sold.....	do.....		Red Lake River water.
14	Poor.....	Poor.....	do.....	do.....	do.....	Poor.....	Butter sold.....	None.....		
15	Good.....	Good.....	Good.....	do.....	do.....	Fair.....	Used on farm.....	do.....		
16	Fair.....	do.....	Fair.....	Fair.....	do.....	Good.....	Sold.....	do.....		
17	Poor.....	Poor.....	Poor.....	Poor.....	do.....	Poor.....	Cream sold.....	Typhoid.....	1	Run River water.
18	do.....	do.....	do.....	do.....	do.....	do.....	do.....	None.....		
19	Fair.....	Good.....	do.....	do.....	do.....	Good.....	Used on farm.....	do.....		

SPRINGS.

1	Poor	Good	Fair	Unprotected vault	Fair	Sold	None	
2	do	do	do	do	Good	Butter sold	do	

RIVERS.

1	Poor	Good	Fair	Unprotected vault	No milk	Used on farm	Typhoid	1
2	do	Poor	Poor	do	Poor	Sold	do	3
3	do	do	do	do	do	do	None	
4	do	Good	do	do	Fair	do	Typhoid	2

SURFACE RESERVOIRS.

1	Poor	Good	Good	Unprotected vault	Good	Used on farm	None	
2	do	do	do	Protected vault	do	do	do	

CISTERNS.

1	Fair	Good	Good	Protected vault	Good	Used on farm	None	
2	do	do	do	do	do	do	do	
3	Good	do	Fair	Unprotected vault	do	Butter sold	do	
4	do	Fair	do	do	Fair	Used on farm	do	
5	do	Poor	Good	do	Poor	do	do	

TABLE IV.—Analytical data concerning the water supplies in Minnesota of which an examination was made.

DUG WELLS.

Physical examination.				Chemical examination.								Bacteriological examination. ^a			
No.	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.	
														1 c.	100 c. c.
1 b	0	0	e 1	520	268	0.056	0.006	0.005	37.00	37.0	Tr.	26	580	—	+
2 b	28	140	e 3	930	830	.34	62.00	.007	.20	115.0	8.00	90	2,550	+	+
3 b	1	4	ed 2	172	194	.024	.028	.001	1.10	4.0	.90	5	135	+	+
4 b	4	24	e 2	64	82	.29	.036	Tr.	.30	31.5	.30	20	7,580	+	+
5 b	1	16	e 2	500	438	.14	.014	.002	22.00	66.0	.10	80	785	—	—
6 b	1	10	me 1	340	310	.084	.028	.008	6.00	115.0	Tr.	22	40	—	—
7 b	0	0	e 1	253	228	.032	.016	Tr.	.50	1.0	.20	5	1,050	+	+
8 b	0	14	e 2	353	279	.25	.056	.012	11.00	30.0	.70	36	900	+	+
9 b	0	3	e 1	215	210	.024	.012	.00	1.40	.5	.40	51	2,200	+	+
10 b	Tr.	11	de 1	407	350	.21	.048	.02	16.00	51.0	Tr.	51	45	+	+
11 b	2	22	em 1	310	279	.34	.067	.07	11.00	73.0	.50	45	2,450	+	+
12 b	0	11	e 3	555	411	.088	.016	.002	21.00	74.0	.40	14	1,450	+	+
13 b	0	17	d 4	740	613	.26	.83	.016	1.60	103.0	.50	74	93	+	+
14 b	0	8	e 3	1,000	385	.25	.036	.008	58.00	175.0	Tr.	41	555	+	+
15 b	1	11	e 1	1,900	301	.19	.016	.011	145.00	630.0	.60	37	435	+	+
16 b	3	16	e 1	500	394	.14	.008	.002	6.00	53.0	.80	24	400	+	+
17 b	0	5	e 2	607	316	.12	.03	.005	45.00	48.5	.10	40	500	+	+
18 b				378	244	.028	.012	.005	27.00	28.0	.10	20	600	+	+
19 b	1	4	e 1	278	254	.032	.012	.001	.80	Tr.	.10	14	1,000	+	+
20 b	3	28	d 4	500	222	.38	.42	.27	52.00	300.0	.40	61	210	+	+
21 b	4	8	e 2	420	336	.062	.066	.036	14.00	22.0	.00	35	325	+	+
22 c	0	0	v 3	429	228	.11	.04	.045	30.00	45.0	.05	28	24	+	+
23 b	0	Tr.	v 1	383	216	.046	.012	.001	5.00	9.0	.40	100	24,300	+	+
24 c	5	35	v 2	182	378	.192	.006	.00	.00	12.0	1.60	23	1,635	+	+
25 c	5	10	v 2	830	688	.054	.012	.08	20.00	40.0	.00	51	23,400	+	+
26 c	15	40	v 2	450	374	.474	.154	.07	35.00	80.0	Tr.	36	2,000	+	+
27 c	15	10	d 3	443	400	.458	.120	.010	.00	10.0	Tr.	51	10,000	+	+
28 c	5	20	e 2	895	540	.330	.072	.025	3.50	185.0	.40	30	2,600	+	+

BORED WELLS.

1 b	3	12	d 4	3,800	545	0.24	0.092	0.05	1.20	11.0	0.50	39	570	+	+
2 c	15	20	v 1	265	480	.076	.120	Tr.	.00	.8	2.00	58	495	+	+
3 c	400	10	e 3	760	540	.256	3.380	.02	.00	85.0	1.20	50	10,000	+	+
4 c	20	0	e 2	479	312	.710	.200	.003	Tr.	110.0	.00	25	10,000	+	+
5													130	+	+
6													380	+	+

DRILLED WELLS.

1 b	4	6	e 1	218	221	0.01	0.012	0.000	0.50	1.5	0.50	7	755	—	+
2 b	0	7	e 2	800	322	1.20	.01	.007	28.00	63.0	Tr.	19	785	+	+
3 b	Tr.	4	e 1	470	270	.08	.026	.001	10.00	102.0	.10	10	220	+	+
4 b	21	10	ed 3	338	388	.07	.15	.015	.15	.5	3.10	26	705	+	+
5 b	2	0	p 4	393	306	.056	Tr.	.002	9.00	9.5	1.10	15	330	+	+
6 b	1	12	m 2	610	394	.08	.066	.028	6.20	33.5	.20	26	2,210	+	+
7 b	2	11	m 2	785	354	.092	.068	.45	28.00	77.0	.20	35	760	+	+
8 c	300	5	e 1	286	460	.052	.814	Tr.	.00	8.0	25.00	98	150	—	—
9 c	5	20	e 1	150	268	.432	1.374	Tr.	.00	100.0	1.20	28	17	—	—
10 c	0	10	v 2	575	452	.152	.064	.10	15.00	65.0	Tr.	70	540	—	—
11 c	0	10	e 1	130	224	.086	.700	.004	.30	115.0	Tr.	9	255	—	—
12 c	50	25	e 1	550	304	.306	.630	.100	3.50	655.0	2.80	40	850	+	+
13 c	25	20	e 1	205	200	.080	.030	Tr.	.00	2.0	2.80	25	10	—	—

^a Bacteriological examination by Dr. A. J. Chesley.^b Chemical and physical examinations by Mr. M. G. Roberts.^c Chemical and physical examinations by Mr. H. A. Whittaker.

TABLE IV.—Analytical data concerning the water supplies in Minnesota of which an examination was made.—Continued.

DRIVEN WELLS.

Physical examination.				Chemical examination.										Bacteriological examination. ^a			
No.	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.			
														1 c. c.	100 c. c.		
1 b	32	m 2	308	338	0.088	0.072	0.005	0.02	2.5	1.90	29	160	80,000	+	+		
2 b	8	md 2	303	341	.18	.10	.003	.02	2.5	6.40	33	256	1,560	+	+		
3 b	22	m 2	260	280	.02	.44	.00	.15	1.0	1.30	3	15	350	—	—		
4 b	0	e 2	310	248	.028	.04	.003	3.80	4.0	.20	15	24	1,560	+	+		
5 b	0	e 1	560	319	.072	.21	.28	13.00	19.0	.25	24	20	29	—	—		
6 b	18	e 2	435	248	.37	.31	.025	2.40	4.0	6.80	20	13	58	—	—		
7 b	6	e 2	445	234	.028	.048	Tr.	Tr.	3.0	2.20	13	11	170	+	+		
8 b	0	e 2	200	236	.02	.004	.00	2.30	3.5	.20	11	10	550	+	+		
9 b	12	em 1	220	218	.04	.01	.003	4.40	6.0	21.00	7	33	25	—	—		
10 b	0	e 1	190	248	.028	.003	.00	.22	Tr.	Tr.	7	10	10	—	—		
11 b	2	e 2	281	260	.010	.002	Tr.	.25	Tr.	.40	35	6	10	—	—		
12 b	200	d 3	2,000	363	.084	1.50	.001	Tr.	3.0	82.00	49	1,250	1,153	+	+		
13 c	3	e 1	253	193	.026	.004	Tr.	5.40	3.0	.50	6	45	1,250	+	+		
14 c	0	e 2	500	412	.444	.022	Tr.	2.50	5.0	.00	45	90	1,153	+	+		
15 b	0	d 2	770	828	2.340	13.400	.220	35.00	165.0	1.20	90	6	65	—	—		
16 b	3	md 2	175	.024	.006	Tr.	3.40	2.0	1.40	.6	11	45	25	—	—		
17 c	0	e 1	300	200	.060	.022	.001	30.00	22.0	.10	14	21	10	—	—		
18 c	0	v 2	620	260	.036	.030	.020	35.00	14.0	Tr.	14	25	—	—	—		
19 c	0	v 2	190	180	.084	1.260	.002	.30	2.0	Tr.	21	10	—	—	—		
10 c	15	v 1	243	200	.068	.240	Tr.	.00	2.0	1.80	18	10	—	—	—		

SPRINGS.

1 b	0	0	m 2	179	176	0.048	0.024	0.009	6.00	3.5	0.05	3	2,200	+	+
2 c	5	15	v 1	1,110	328	.238	1.050	.033	.00	2,350.0	1.60	52	1,000	+	+

RIVERS.

1 c	10	50	v 3	176	140	0.580	0.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
2 c	10	50	v 3	176	140	.580	.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
3 c	15	25	v 2	176	146	1.084	.390	0.00	0.00	5.0	Tr.	8	10,000	+	+

SURFACE RESERVOIRS.

1 c	160	40	v 2	1,530	112	3.014	0.860	Tr.	0.00	4,100.0	8.00	62	2,000	+	+
2 c	5	30	v 3	457	176	1.846	1.410	0.080	.00	505.0	.00	23	890	+	+

CISTERNS.

1 c	0	30	v 1	22	36	0.235	0.260	0.007	0.30	5.0	0.00	3	1,600	+	+
2 c	5	30	v 1	32	32	.390	.623	.00	.00	10.0	.00	11	1,000	+	+
3 c	5	20	v 1	30	8	.214	.446	Tr.	.00	10.0	.40	5	1,000	+	+
4 c	5	55	v 2	40	12	.504	.490	.005	.00	50.0	.00	13	80,000	+	+
5 c	5	30	v 2	64	36	.560	.042	.00	.00	80.0	Tr.	7	1,000	+	+

^a Bacteriological examination by Dr. A. J. Chesley.^b Chemical and physical examinations by Mr. M. G. Roberts.^c Chemical and physical examinations by Mr. H. A. Whittaker.

A review of the foregoing data shows that of the 79 supplies examined 20 furnished water of a satisfactory quality, while 59 were more or less seriously polluted. It must be remembered, however, that, other conditions being similar, bad supplies are of greater interest to the sanitary investigator and are selected for study, as it is

these supplies which indicate the dangers to be avoided. Therefore, the percentage of unsanitary supplies is much larger than would be found if examination had been made of all the rural water supplies of any large area. The actual proportion of polluted supplies in rural districts may at present be assumed to be about 35 per cent.^a

The distinction between good and bad supplies is of course an arbitrary one. In accordance with the modern ideas upon this subject the greatest dependence is placed upon personal inspection of the environment of any supply in question,^b the bacteriological data being next in importance.

Interpreted in the light of the field observations the bacteriological examination gives the best evidence of actual pollution, in spite of the difficulty of determining the significance of the so-called sewage organism, *Bacillus coli*. The more or less ubiquitous character of this bacillus^c does not, however, entirely destroy its value as an indicator of pollution. It must be remembered that typhoid fever, popularly the most dreaded disease, is by no means the only one that the water sanitarian is called upon to prevent. The great decrease in death rate, exclusive of deaths from typhoid, which follows the installation of a bacteriologically pure water supply^d shows the necessity for extending the idea of a polluted water beyond the mere possibility of its serving as the carrier of typhoid bacilli. With the

^a Kellerman, K. F., and Beckwith, T. D. *Bacteria of the Dairy Wells in the Vicinity of Washington, D. C., and Their Possible Relation to Typhoid Fever at Washington*. Engineering News, vol. 57, No. 6, p. 152. 1907.

^b Leighton, M. O. *The Futility of a Sanitary Water Analysis as a Test of Potability*. Biological Studies by the Pupils of W. T. Sedgwick, pp. 36-53. Boston, 1906.

Dole, R. B. *Sanitary Inspection vs. Sanitary Analysis*. American Public Health Association, vol. 31, part 1, pp. 59-67. 1905.

^c Dyar, H. G., and Keith, S. C. *Notes on Normal Intestinal Bacilli of the Horse and of Certain Other Domestic Animals*. Technology Quarterly, vol. 6, pp. 256-257. 1893.

Moore, V. A., and Wright, F. R. *Observations on Bacillus Coli Communis from Certain Species of Domesticated Animals*. American Medicine, vol. 3, No. 13, pp. 504-507. March, 1902.

Eyre, J. W. H. *On the Distribution of Bacillus Coli in Nature*. The Lancet, vol. 1, No. 10, pp. 648-649. 1904.

Johnson, George A. *Isolation of Bacillus Coli Communis from the Alimentary Tract of Fish and the Significance Thereof*. Journal of Infectious Diseases, vol. 1, No. 2, pp. 348-354. 1904.

Prescott, S. C. *The Occurrence of Organisms of Sanitary Significance on Grains*. Biological Studies by the Pupils of William Thompson Sedgwick, pp. 208-222. Boston, 1906.

Flint, J. M. *Notes on Distribution of Bacillus Coli Communis*. Journal of American Medical Association, vol. 26, pp. 410-411. 1896.

^d Hazen, Allen. *Purification of Water in America*. Transactions of the American Society of Civil Engineers, vol. 54, part D, pp. 131-154. 1905.

Whipple, George C. *The Value of Pure Water*, pp. 9-12. New York, 1907.

assumption, therefore, that minor and indefinite or undescribed intestinal disturbances play a considerable part in the death rate due to polluted water, that much-discussed organism *Bacillus coli* may still fairly be taken as representing by its presence a more or less objectionable pollution, as it is essentially an intestinal inhabitant, whether of human or other animal origin. The degree of pollution must be determined from the total count of bacteria, supplemented by the chemical analyses, and from the field observations.

RURAL TYPHOID FEVER.

The vital statistics of the country are even less satisfactory than those of the city, and in spite of the emphasis that has recently been given to the importance of rural typhoid^a it is at the present time impossible to determine whether typhoid fever is essentially an urban disease, as has been generally supposed, occasionally transmitted into other districts, or whether rural typhoid exists as such, independent of city infection. In the Minnesota studies the origin of many cases was untraceable, perhaps because typhoid fever is a disease carelessly or irregularly reported to the State Board of Health by the attending physicians, and for practical purposes it is necessary for the present to assume that in any rural district typhoid fever may suddenly develop.

During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 possible sources were determined, and on 10 farms the data seemed to locate definitely the source of infection. The water supplies furnishing data which more or less definitely located the source of typhoid infection will be briefly noted.

Farm No. 12, under dug well type. One case during 1908, a boy 15 years of age, taken sick July 18. For some weeks before the boy became ill the city of Mankato, Minn., had been suffering from a severe typhoid epidemic, due to an infected city water supply.^b The boy, who delivered milk in the city, drank water from the city supply on a number of occasions before his illness. He was immediately removed to the city hospital and no other cases developed on the farm.

Farm No. 3 under bored well type. Six cases during the spring of 1908. The first case was brought from Oslo, Minn., where the patient had been employed as a servant in one of the hotels. The secondary cases may have been due to contact or to water pollution.

Farm No. 5 under driven well type. Three cases during 1907; apparently infected in Minneapolis.

^a Whipple, G. C. Typhoid Fever, pp. 112-114. New York, 1908.

^b Established by extensive investigations made by the Minnesota State Board of Health.

Farm No. 12 under driven well type. Two cases during 1908; the first, a girl 16 years old, was taken sick July 14, and the second, a boy 14 years old, was taken sick July 25. Both of the infected people attended a circus at Wadena, Minn., June 27, on which occasion they drank city water, water on the railroad train, and circus lemonade. On July 10 they attended a second circus at Henning and drank water from several sources. The data collected indicate quite clearly that the disease was contracted during attendance at the Wadena circus, June 27.

Farm No. 17 under driven well type. One case during 1907, a man taken sick October 10. September 19 to 21 he had attended a street fair at Anoka, Minn., and drank water from the city drinking fountain. Several cases of typhoid were present in the city of Anoka and were supposed to have been infected by the city supply.^a

Farm No. 2 under drilled well type. Three cases during 1908; the first two, a man and a woman, taken sick July 7, the third, a woman, taken sick July 17. The well on this place is badly located and receives surface wash from the entire yard. The privy is so located that during heavy rains, which occurred at the period of the year previous to the infection, the surface wash from that direction reaches the well.

RURAL TYPHOID EPIDEMIC FROM THE RED LAKE RIVER.

A small rural epidemic occurred during the investigation in the Red River Valley and included three farms in a sparsely populated region.

Farm No. 13 under driven well type and farm No. 4 under "Rivers." Two cases in 1908; a girl 19 years old, taken sick February 10, and a boy 13 years old, taken sick March 10. The girl had not been away from the farm for at least six weeks preceding her illness and no other cases of typhoid were present in the community. During the winter season until February 25 the water supply was the Red Lake River, which flows near the house. At a point called Huot, several miles up the Red Lake River from this farm (see farms No. 2 under "Rivers" and No. 26 under "Dug wells"), four cases of typhoid occurred during the spring season; the first, a boy 10 years old, taken sick February 15; the second, a man 40 years old, taken sick February 28; the third, a boy 7 years old, taken sick April 19. None of these patients had visited any other district before or after their infection. The other case of this infected group was a man 38 years old who was taken sick April 1. (See farms No. 1 under "Rivers" and No. 26 under "Dug wells.") From February 28 until the date of illness he had remained constantly with his brother. (See farm No. 2 under

^a Data furnished by the Minnesota State Board of Health.

"Rivers.") He drank Red Lake River water from November 15 until the date of his illness. This case may be one of contact or of direct infection from the original source, the Red Lake River.

The cities contributing sewage or drainage above the point of infection are St. Hilaire, Red Lake Falls, and Thief River Falls. During the winter season there are lumber camps scattered along the Red Lake River beyond Thief River Falls, and these also might play some part in the pollution. The river also flows through a part of the Red Lake Indian Reservation.

SUMMARY AND CONCLUSIONS.

(1) Both farm and city are suffering from the careless management of rural sanitation.

(2) Previous investigations of rural water supplies have been more or less unsatisfactory, due either to the local or fragmentary character of the investigations or to the use of a single method in studying the supplies in question.

(3) Exhaustive data upon 79 carefully selected and typical rural water supplies show that 20 were good and, usually because of careless or ignorant management, that 59 were polluted.

(4) Of the polluted wells, 11 are so located that even extreme care would not make them safe; 10 are poorly located, but improvements in the protection from surface wash and infiltration would make them safe; 25 are bad only because of poor surface protection and could easily be made safe; 1 is polluted from unknown, probably distant, sources. Onesprings supply is polluted because of poor surface protection and could easily be made safe. The rivers, surface reservoirs, and cisterns are polluted, and it is doubtful whether satisfactory supplies can be secured for farm use from such sources. Where their use is necessary, water for drinking should be boiled or otherwise disinfected.

(5) During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 farms possible sources were determined, while on 10 the data seemed to locate definitely the source of infection. The water supplies upon 5 of these farms were not polluted and the infection was traceable to outside sources; the water supplies of the remaining 18 farms were polluted.

(6) The protection of farm supplies by common-sense methods obvious to anyone who will try to discover the dangers incident to his own water supply would render safe the majority of the farm supplies which are now polluted. Exhaustive studies of rural conditions at the present time, therefore, are warranted only in connection with epidemiological studies.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 155.

B. T. GALLOWAY, *Chief of Bureau.*

THE CONTROL OF BLACK-ROT OF THE GRAPE.

BY

C. L. SHEAR, PATHOLOGIST,

AND

GEORGE F. MILES AND LON A. HAWKINS,

SCIENTIFIC ASSISTANTS, FRUIT DISEASE INVESTIGATIONS.

ISSUED AUGUST 30, 1909.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 10, 1909.

SIR: I have the honor to transmit herewith a paper entitled "The Control of Black-Rot of the Grape," a report of three seasons' spraying experiments by Dr. C. L. Shear, Pathologist, and Messrs. George F. Miles and Lon A. Hawkins, Scientific Assistants, of this Bureau, and recommend its publication as Bulletin No. 155 of the series of the Bureau of Plant Industry.

The paper contains the results of grape spraying experiments conducted in New York, New Jersey, Pennsylvania, and Michigan. The work shows conclusively that the most serious epidemics of black-rot, such as prevailed in Michigan, can be satisfactorily controlled by thorough and proper methods of spraying. It also indicates that smaller quantities of copper sulphate and lime than have heretofore been thought necessary in the preparation of Bordeaux mixture will give just as satisfactory results as the stronger mixtures.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE CONTROL OF BLACK-ROT OF THE GRAPE.

INTRODUCTION.

Ever since the beginning of commercial grape growing in the eastern United States, black-rot has been one of the most serious enemies with which vineyardists have had to contend. It is now more than twenty years since the introduction of spraying for grape diseases in this country. During this period much work upon this subject has been done by the Department of Agriculture and the State agricultural experiment stations, and as a result many improvements have been made in the formulas and the preparation of fungicides, and in the methods of applying them. These have resulted in much more efficient work and also in a reduction of the cost of the operations.

The continued success of commercial grape growing in any of the humid portions of this country has heretofore largely depended upon the successful control of the fungous diseases. Virginia, North Carolina, Florida, southern Ohio, Missouri, and New Jersey have each during the last seventy-five years been important grape-growing centers. Grape growing has arisen and flourished in various parts of the eastern United States only to decline and be largely abandoned after having passed through a severe epidemic or series of epidemics of black-rot. Notwithstanding the success which has been attained in recent years by the Department of Agriculture and the agricultural experiment stations, these outbreaks are not usually satisfactorily controlled by the growers. Black-rot still causes heavy losses and continues to threaten the industry in various localities.

Unsatisfactory results from spraying are according to our observations most generally due to lack of thoroughness in the application of the fungicide. In many cases improperly prepared mixtures and poor apparatus are also important causes of failure. Without an opportunity to observe in actual operation the various processes connected with the proper preparation and application of fungicides, it seems to be difficult for many persons to carry out satisfactorily the most successful methods of spraying. One who undertakes spraying for the first time and does the work, as he thinks, in accordance with the best method and yet only meets with indifferent success or failure is quite likely to lose confidence in the treatment or to condemn it entirely. It is therefore very important that the subject

should be thoroughly understood and the work properly carried out from the beginning.

Owing to the failure of many vineyardists in their efforts to prevent black-rot, a series of investigations was undertaken to demonstrate the efficiency of the best methods at present practiced and at the same time to improve, if possible, both methods and mixtures and also to secure more accurate knowledge of the life history and habits of the black-rot fungus and of the other parasitic fungi which are more or less destructive to the grape. This work was commenced in the spring of 1906 at North East, Pa. In 1907 it was extended to central New York and Michigan, and the past season, 1908, it has been carried on in Pennsylvania, New York, Michigan, and New Jersey. In order to determine the various factors influencing the black-rot fungus and its successful control, as well as the relative importance and relation of these factors, it seemed necessary to carry on the work at different points which should represent different soils and climatic conditions as well as with different varieties of grapes and methods of training and cultivation.

THE CAUSE OF BLACK-ROT.

Black-rot is caused by a parasitic fungus known botanically as *Guignardia bidwellii*. It is a vegetable organism which reproduces and spreads by means of minute microscopic bodies called spores. These are borne in small black globose bodies which may be seen covering the surface of mummied grapes which have been destroyed by rot. This parasite produces two well-known spore forms, as shown in figure 1. These are somewhat similar in appearance and differ chiefly in the way in which they are produced. The so-called summer spores are borne on the ends of small, slender threads, and when mature are set free and escape in white tendril-like masses through an opening at the apex of the minute spore case. This form usually occurs first upon the grape leaves in the shape of small black pustules scattered over a reddish or whitish more or less circular dead spot. If a little later the weather conditions are favorable the fungus may be found attacking the flower buds or very young fruit, which may be destroyed at any time from the setting of the fruit to near the maturity of the berries. Fruit which is attacked when very young turns black and soon drops off, and this stage of the disease is frequently called blight or blast. Later, when the berries are one-third grown or larger, the disease usually starts in the form of a sordid white spot, which increases more or less rapidly in size until the whole berry is affected and begins to shrivel, and sooner or later becomes covered with the minute black pustules of the black-rot fungus. What is frequently called "bird's-eye," or anthracnose, by growers in New York and Pennsylvania is a condition of development due to

the black-rot fungus and is not the true anthracnose. A form of the disease in which the berries rot rapidly and become soft is sometimes called soft-rot. Besides the leaves and fruit the fungus also attacks the young shoots, producing numerous small, reddish brown spots.

During the autumn and winter the fungus continues to grow when conditions are favorable, and the second spore form is produced. These spores, sometimes called winter spores, grow inside of a minute sac and are usually eight in number, as shown in figure 1, c. These sacs with their spores are produced inside of small black pustules very closely resembling those which contain the free summer spores. There are several points in regard to the life history of this fungus and the various means by which infection is accomplished which are not yet thoroughly understood, and much more work is needed to verify and extend our knowledge of these matters.

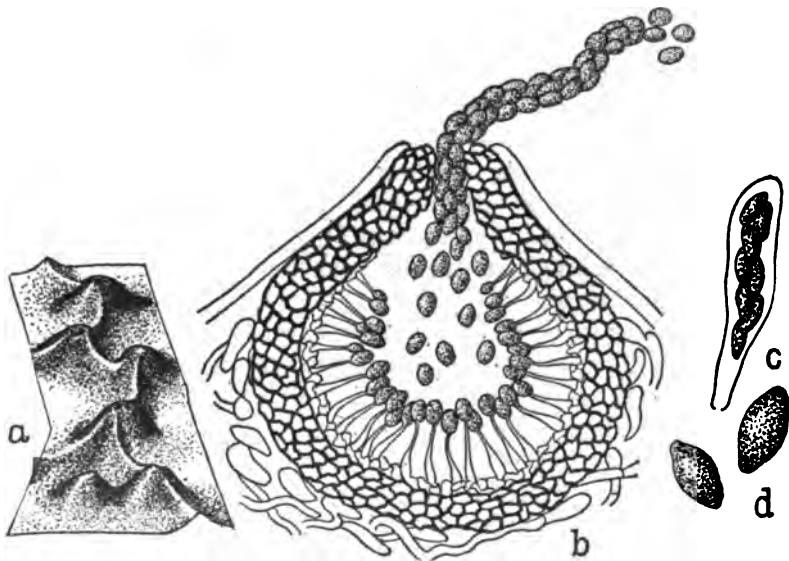


FIG. 1.—The black-rot fungus (*Guignardia bidwellii*): a, A portion of an affected grape, showing the pustules in which the spores are produced (slightly magnified); b, a section of one of these pustules very highly magnified, showing the manner in which the summer spores are produced and discharged; c, a sac containing winter spores; d, single winter spores very highly magnified.

The first infection of the young foliage and buds in the spring is believed to come from the winter spores which are expelled from the mature fruiting pustules of the fungus and are driven by the wind and rain to the young growing parts of the vine. These spores are usually produced upon the old black-rot mummies from spring until late summer whenever sufficient moisture in the form of rain, fog, or dew is present, and they are regarded as a source of infection during that period. The fungus having gained entrance to the leaves, shoots, or young fruit may immediately begin to produce the summer spores which, when discharged and distributed to the fruit and other

parts of the plant, may produce further infection and disease. So far as known at present, after the fungus has gained entrance to the tissue of the leaf or has gotten beneath the skin of the berry its further development under favorable climatic conditions can not be prevented by any practical means; hence, all measures to be undertaken against the disease must be directed toward preventing the fungus from gaining entrance to the plant and reproducing itself. The winter spores borne upon the old mummied grapes are regarded as one of the chief sources of early infection, and any practical means of destroying or preventing the distribution of these spores should tend to restrict the spread of the disease. That this is a matter of great importance has been shown by observations made during the course of this work. Vines located near unsprayed plants in an adjoining vineyard which had an abundance of black-rot mummies were much more seriously affected by the rot than those which were farther removed from this source of infection. Where black-rot is serious it will be found profitable, in the opinion of the writers, to destroy or bury all the old mummied grapes in the vineyard. At the time of pruning, all diseased grapes which are still hanging on the vines should be picked and burned or buried deeply and all the mummies on the ground should be either raked up and burned or else buried deeply by plowing. All the prunings from the vineyard should also be destroyed by burning, as the diseased shoots may produce spores of the black-rot fungus.

Having destroyed or removed as far as practicable the source of infection, the next step is to protect the entire plant as nearly as possible from any spores which may reach it, and this is accomplished in practice by spraying with fungicides. These are composed of chemicals which prevent the germination of the fungous spores with which they come in contact. If, therefore, every portion of a grape plant which may form a point of entrance for the fungus is covered with a film of a fungicide like Bordeaux mixture, any spores which may be present at the time the fungicide is applied or any others which may fall upon the plant before the fungicide has been washed off or removed in any way will be destroyed; hence, what is desired in spraying is to cover the plant as nearly as possible with a very thin film of the fungicide and to keep the plant covered during the portion of the season when infection is likely to occur. In order to accomplish this, the very best nozzles and spraying machines must be used and handled by persons who are very careful and thorough in their work. The fungicides used must be carefully prepared according to the best methods and formulas.

The technical investigations of the various problems have not yet been completed; therefore, only the results of immediate practical importance are reported at this time.

THE FUNGICIDES USED.

In the trial of various fungicides several purposes were kept in view: First, the efficiency of the fungicide; second, its economy as determined by the cost of material and its preparation and application; and, third, in the case of nonstaining applications, efficiency as compared with cost and injury to the fruit by staining. Following are the formulas of the different preparations used:

Bordeaux mixture.—Commercial copper sulphate, fresh stone lime, and water, in the order given, were prepared according to the following formulas:^a

6-3-50 (For first application only, before buds burst.)

5-5-50

5-4-50

5-3-50

4-4-50

4-3-50

4-2-50

3-3-50

3-2-50

3-1-50 (For final application only.)

According to recent investigations of the chemistry of Bordeaux mixture made by Pickering,^b the addition of a greater quantity of lime than is sufficient to neutralize the copper sulphate and render it slightly alkaline interferes with the efficiency of the mixture as a fungicide. He maintains that any excess of lime must first be oxidized and disappear before the copper can be acted upon and become effective; thus, any excess of lime tends to retard the fungicidal action of the mixture and should never be added except for the purpose of protecting foliage which would be injured by mixtures not containing an excess of lime. Experiments made by Kelhofer^c to determine the difference in the adhesive qualities of mixtures made with different quantities of lime gave the best results when two parts by weight of copper sulphate were used with but one part of lime. Such a mixture would be represented by our 4-2-50 formula. To the weaker solutions of Bordeaux mixture resin-fishoil soap was added for one or more of the applications to improve their adhesive qualities.

Burgundy mixture.—Three formulas were used: (1) Composed of 1½ pounds of copper sulphate and 2 pounds of sodium carbonate to 50

^a Whenever formulas for Bordeaux mixture are given in this paper the first number indicates the number of pounds of copper sulphate used; the second, the number of pounds of stone lime; and the last, the number of gallons of water.

^b Pickering, Spencer. Interaction of Metallic Sulphates and Caustic Alkalis. Proc. Chem. Soc., vol. 23, p. 261. London, 1907.

^c Kelhofer, W. Ueber einige Gesichtspunkt bei die Herstellung der Bordeauxbrühe. Inter. Phytopath. Dienst., vol. 1, p. 65. 1908.

gallons of water; (2) composed of 1 pound of copper sulphate and $1\frac{1}{2}$ pounds of sodium carbonate to 50 gallons of water; (3) composed of $1\frac{1}{2}$ pounds of copper sulphate and $1\frac{1}{2}$ pounds of sodium carbonate to 50 gallons of water. The ingredients were dissolved separately and mixed in a dilute condition.

Perdeux mixture.—This is a preparation which was found in use in France and was very highly recommended. An analysis of a sample by the Bureau of Chemistry showed that it consisted of a mixture of pulverized copper sulphate and sodium carbonate, being essentially a form of Burgundy mixture. Preparing this in about the same proportions as indicated by the analysis, we have the following formula: 5 pounds of copper sulphate, 2 pounds of sodium carbonate, and 50 gallons of water. As might be expected from comparison with the formulas of the same constituents used in the Burgundy mixture, it was found impracticable to use this mixture on account of its severe injury to the foliage.

Sodium benzoate Bordeaux mixtures.—These mixtures were prepared as follows: (1) 2 pounds of copper sulphate, 1 pound of lime, and 1 pound of sodium benzoate to 50 gallons of water; (2) 1 pound of copper sulphate, 1 pound of lime, and one-half pound of sodium benzoate to 50 gallons of water. The ingredients were dissolved separately and mixed in a dilute condition.

Copper borate mixture.—Mixtures of this fungicide were prepared according to the following formulas: (1) $1\frac{1}{2}$ pounds of copper sulphate, 2 pounds of borax, 50 gallons of water; (2) $1\frac{1}{2}$ pounds of copper sulphate, 2 pounds of borax, 50 gallons of water; (3) 1 pound of copper sulphate, 2 pounds of borax, 50 gallons of water. Resin-fishoil soap was also added to most of these mixtures to improve their adhesive qualities and to determine the benefit to be derived from this source.

Ammoniacal copper carbonate.—This spray was prepared with 5 ounces of copper carbonate and 3 pints of ammonia to 50 gallons of water.

Copper chlorid mixture.—Prepared according to the following formula: 4 ounces of copper sulphate, 2 ounces of calcium chlorid, 50 gallons of water, with the addition of 1 pound of resin-fishoil soap.

Normal copper acetate solution.^a—Prepared with one-half pound of normal copper acetate to 50 gallons of water.

Neutral copper acetate solution.^b—Prepared by dissolving 1 pound of neutral copper acetate in 50 gallons of water.

^a The copper acetate used in some of the experiments was supplied under the name of normal copper acetate.

^b In the work of 1908 all material used was purchased from the same source and labeled "neutral copper acetate." This form of copper acetate, the writers believe, is least apt to injure foliage and gives very good results as a fungicide.

Basic copper acetate (verdigris solution).—Prepared by dissolving 5 ounces of basic copper acetate in 50 gallons of water.

Copper sulphate solution.—Prepared with 3 pounds of copper sulphate to 50 gallons of water. Used as a dormant application only.

Self-boiled lime-sulphur.—(1) Prepared by mixing 8 pounds of flowers of sulphur with 15 pounds of stone lime, with the addition of hot water, diluting the whole to 50 gallons; also (2) 10 pounds of sulphur to 15 pounds of lime, with the same quantity of water.

"A" brand concentrated lime-sulphur.^a—This mixture was used in two strengths: (1) 1 gallon of the concentrated preparation added to 50 gallons of water, and (2) 1 gallon added to 75 gallons of water.

"B" brand concentrated lime-sulphur.^a—Prepared with 1 gallon of the concentrated solution added to 50 gallons of water.

METHOD OF MIXING.

The writers have practiced in all cases the method of preparing Bordeaux mixture which has heretofore been described in many of the publications of the Department of Agriculture and which is given in Farmers' Bulletin No. 284 in connection with the treatment of fungous diseases of the grape.

The copper sulphate and the lime are each diluted separately and thoroughly mixed together in a dilute form. Modifications of this method are said by some American and European pathologists to give equally good results, but the writers have not tested them as yet sufficiently to express an opinion.

WORK IN PENNSYLVANIA.

EXPERIMENTS IN 1906.

For several years preceding 1906, the time this work was commenced, an epidemic of black-rot had prevailed in the grape belt in northwestern Pennsylvania, the center of which is North East. The work at this point was undertaken through an understanding with the Pennsylvania State College Agricultural Experiment Station and at the earnest solicitation of the grape growers.

The vineyard selected for the work consisted of 12 acres of Concord vines about 17 years old. The plots were 1.6 acres each and consisted of 10 rows, running east and west. There had been some loss from black-rot the preceding year, but it was not severe. The mixture used just before the leaf buds had opened was 6-4-50 Bordeaux, applied on May 5. Other fungicides used during the season were 5-5-50 Bordeaux mixture, Perdeux mixture,^b Burgundy mix-

^a These are commercial preparations generally obtainable.

^b The composition of these mixtures is given on pages 11-13.

ture and 1 pound of resin-fishoil soap, and ammoniacal copper carbonate solution. Lead arsenate was also added for rootworms which were affecting the vineyard.

Seven applications of Bordeaux mixture were made on one plot, six on another, and four on another. Five applications of the Burgundy mixture and the ammoniacal copper carbonate solution were also tried.

The season was rather dry and unfavorable for the development of black-rot, so that there was no appreciable loss from this cause on the unsprayed check plot. There was, however, some injury from powdery mildew, which began to attack the foliage early in July, so that the principal benefit derived from the spraying was apparently due to the prevention of injury from this mildew. There was so little difference in the fruit of the different plots at picking time that it did not seem advisable to attempt to pick and sort separately the crop from each of the plots.

Plot 5, which had received four applications of 5-5-50 Bordeaux mixture, was picked and graded separately and compared with the fruit picked from the check plot. The check plot produced 2,195 4-pound baskets, and the sprayed plot 2,170 4-pound baskets. The principal profit apparently derived from spraying is indicated by the small quantity of culls or wine grapes present. On the check plot 15 per cent of the fruit consisted of culls, while on the sprayed plot there were only 8 per cent of culls. The fruit on the sprayed plot was also firmer and of much better keeping quality, according to the report of the buyer who packed and handled it. It will be noted, however, that on the check plot there were 25 baskets of fruit more than were on the sprayed plot. This was perhaps due to the fact that the check plot happened to contain some more vigorous and productive vines than the sprayed plot. This is always a source of some error in computing results. Even where the vines are of the same number and the same age there will always be some which are naturally more productive than others. The spraying outfit used in this work was a geared traction sprayer.

The following table shows the treatment of sprayed plot 5:

TABLE I.—*Treatment given plot 5 at North East, Pa., in 1906.*

Date of spraying.	Fungicide used.	Stage of growth.
June 8.....	5-5-50 Bordeaux mixture.....	Just before blooming.
June 26.....	5-5-50 Bordeaux mixture plus lead arsenate.....	Berries all set.
July 9.....	5-5-50 Bordeaux mixture plus lead arsenate and soap.	Berries size of peas.
July 25.....	$\frac{1}{2}$ pound copper sulphate to 50 gallons of water....	Berries three-fourths grown.

EXPERIMENTS IN 1907.

The work was continued in the same vineyard in 1907. The following fungicides were used: 5-5-50 Bordeaux mixture; 4-4-50 Bordeaux mixture; Burgundy mixture No. 1, plus 1 pound of resin-fishoil soap; Burgundy mixture No. 2, plus 1 pound of resin-fishoil soap; copper borate mixture No. 1; basic copper acetate solution, 5 ounces to 50 gallons of water; and copper chlorid mixture with 1 pound of resin-fishoil soap.

The first applications were made with a gasoline-engine outfit, as illustrated in figure 2. Subsequent applications were made with geared traction sprayers.

The weather conditions during 1907 were also dry and unfavorable for the development of black-rot, so that there was no loss from this cause on the check plot. There was, however, some injury from powdery mildew, as in 1906.

Plot 4 was selected for comparison with the check plot. This plot had been sprayed with 4-4-50 Bordeaux mixture, with 2 pounds of resin-fishoil soap added for the first four applications. From the check plot 1,024 8-pound baskets were picked, and 1,220 8-pound baskets from sprayed plot 4. This shows an increase of 15 per cent of fruit on the sprayed plot. The percentage of culls, according to the report of the packers, was the same from each plot, and the additional quantity of fruit on the sprayed plot could not perhaps be justly attributed entirely to the effect of spraying. The same difference of productiveness of individual vines probably enters in this case as in that already referred to in 1906.

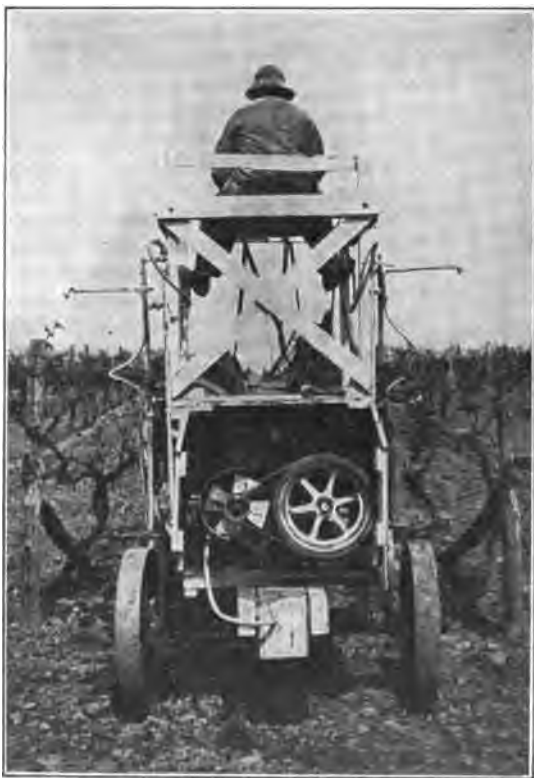


FIG. 2.—Gasoline-engine outfit used in spraying at North East, Pa., in 1907.

The following table shows the treatment of plot 4:

TABLE II.—*Treatment given plot 4 at North East, Pa., in 1907.*

Date of spraying.	Fungicide used.	Stage of growth.
June 15-17.....	4-4-50 Bordeaux mixture plus 2 pounds of soap..	Shoots 8 inches to 1 foot long.
July 9-10.....	do	Just before blooming.
July 20.....	4-4-50 Bordeaux mixture.....	Just after blooming.
August 9.....	Copper borate mixture.....	Berries three-fourths grown.

EXPERIMENTS IN 1908.

Work was continued in the same vineyard in 1908. The plots used covered four-fifths of an acre. Three applications each of the following mixtures were made: "A" brand concentrated lime-sulphur, 1 gallon to 50 gallons of water; Bordeaux mixture, 4-4-50, 4-3-50, and 3-2-50. The lime-sulphur burned the foliage and apparently can not be safely used in this strength on grapes. This opinion is also corroborated by the writers' experience in New York and Michigan.

This season, also, weather conditions were not favorable for the development of rot, and the benefit derived from the spraying consisted chiefly in the prevention of powdery mildew.

The yield from six of the plots was as follows:

TABLE III.—*Yield of grapes from six four-fifth-acre plots at North East, Pa., in 1908.*

No. of plot.	Fungicide used.	Yield, 8-pound baskets.
1	"A" brand lime-sulphur, 1 gallon to 50 gallons of water.....	432
2	4-4-50 Bordeaux mixture.....	554
3	4-3-50 Bordeaux mixture.....	478
4	4-2-50 Bordeaux mixture.....	479
5	3-2-50 Bordeaux mixture.....	430
6	Check, unsprayed.....	404
7	4-2-50 Bordeaux mixture.....	(*)
8	3-2-50 Bordeaux mixture.....	(*)

* No record.

It will be noted that the largest amount of fruit (554 baskets) came from plot 2. All sprayed plots produced greater amounts of fruit than the check; the increase varied from 26 to 150 baskets. Here, again, it is probable that the difference in production of individual vines has affected the result, though there was a decided benefit to the vines on all of the sprayed plots, as shown by the healthy foliage, freedom from mildew, and the general vigor and thriftiness of the plants.

The following table shows the treatment of plot 2:

TABLE IV.—*Treatment given plot 2 at North East, Pa., in 1908.*

Date of spraying.	Fungicide used.	Stage of growth.
May 25.....	4-4-50 Bordeaux mixture plus 6 pounds of arsenate of lead.	Shoots 8 inches long.
June 17.....	4-4-50 Bordeaux mixture.....	Through blooming.
July 21.....	do.....	Berries about three-fourths grown.

From the point of view of the prevention of black-rot alone the experiments conducted at North East gave no important results, but it is believed that they have considerable significance on account of their bearing upon the question of the desirability of annual spraying as a regular practice and as a matter of insurance.

It is the belief of some of the best grape growers, as well as of the writers, that the spraying in this vineyard has proved profitable. Though the actual amount of profit each season in dollars and cents may not have been great, the general effect upon the vineyard is very noticeable when it is compared with other vineyards of about the same age which have been treated in about the same manner with the exception of spraying. The general health, vigor, and productiveness of the sprayed vineyard is very noticeable, and this condition can probably now be preserved with perhaps only three applications each season.

The so-called "dead-arm," or necrosis as it has been named by Reddick,^a is a more serious matter in the Pennsylvania grape belt at present than black-rot. This disease has been under investigation for several years, but the work is not yet completed. Our experiments indicate that spraying alone is not likely to prove an effective means of controlling this trouble.

WORK IN NEW YORK.

EXPERIMENTS IN 1907.

The investigation of grape diseases, with spraying experiments, was commenced in the spring of 1907 in a large vineyard of Niagara grapes in charge of Mr. C. E. Smith at Kendaia, N. Y. The plots were 1 acre each, and the vines about 20 years old. The rows ran north and south. The vineyards in this region had suffered greatly from black-rot for several years and the growers had lost faith in the efficiency of the ordinary methods of preventing the disease. This work was

^a Reddick, Donald. Necrosis of the Grapevine. Bulletin 263, Cornell University Agricultural Experiment Station. 1909.

part of a general plan for a thorough investigation of the grape diseases of the country and their control, and especially their relations to different varieties, soils, and climatic conditions. This locality afforded exceptional opportunities for the study of certain of the grape-disease problems, especially in their relation to the Niagara grape. An urgent invitation from the growers was accepted, and through an understanding with the Cornell University Agricultural Experiment Station the work was commenced. The results of the spraying experiments for the seasons of 1907 and 1908 are here given. The technical pathological investigations are not yet ready for publication.

The fungicides used were Bordeaux mixture, 5-5-50 and 4-4-50, with and without the addition of resin soap; Burgundy mixture, No. 1 and No. 2, and 1 pound of resin soap; copper borate mixture No. 1 and 1 pound of resin soap; normal copper acetate and one-half pound of resin soap; copper chlorid with 1 pound of resin soap. Wherever soap is mentioned the resin-fishoil soap, which was used as an adhesive, is meant.

Ten plots of 1 acre each were selected for the spraying experiments. Plot 7 was a check and received no treatment. The following table shows the treatment of the different plots:

TABLE V.—*Treatment given nine plots at Kendaia, N. Y., in 1907.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 22.....	5-5-50 Bordeaux mixture.....	Buds $\frac{1}{2}$ to 1 inch long.
June 11.....	do.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Burgundy mixture No. 2.....	Berries grown.

PLOT 2.

May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 22.....	4-4-50 Bordeaux mixture.....	Buds $\frac{1}{2}$ to 1 inch long.
June 11.....	do.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Normal copper acetate.....	Berries grown.

PLOT 3.

May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 21.....	4-4-50 Bordeaux mixture, with 2 pounds of soap..	Buds $\frac{1}{2}$ to 1 inch long.
June 11.....	4-4-50 Bordeaux mixture.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Copper borate only.....	Berries grown.

TABLE V.—Treatment given nine plots at Kendaia, N. Y., in 1907—Continued.

PLOT 4.

Date of spraying.	Fungicide used.	Stage of growth.
May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 22.....	Copper borate, with 2 pounds of soap.....	Buds $\frac{3}{4}$ to 1 inch long.
June 11.....	do.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Copper borate only.....	Berries grown.

PLOT 5.

May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 22.....	Burgundy mixture No. 2.....	Buds $\frac{3}{4}$ to 1 inch long.
June 11.....	do.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Burgundy mixture only.....	Berries grown.

PLOT 6.

May 10.....	6-3-50 Bordeaux mixture.....	Buds swelling.
May 22.....	Copper chlorid mixture.....	Buds $\frac{3}{4}$ to 1 inch long.
June 11.....	do.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	do.....	Berries grown.

PLOT 8.

June 11.....	5-5-50 Bordeaux mixture.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.

PLOT 9.

June 11.....	4-4-50 Bordeaux mixture and 2 pounds of soap..	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	4-4-50 Bordeaux mixture.....	Berries three-fourths grown.

PLOT 10.

June 11.....	Copper borate mixture.....	Shoots 8 inches to 1 foot long.
June 28.....	do.....	Beginning to bloom.
July 13.....	do.....	Berries size of small peas.
July 25.....	do.....	Berries one-half grown.
August 2.....	do.....	Berries three-fourths grown.
August 13.....	Normal copper acetate.....	Berries grown.

The weather conditions during the season were not so favorable for the development of rot as they had been the year previous. On the unsprayed check plot the first indications of disease were found, as shown by spots on the leaves, on July 11. There was an outbreak of rot on the fruit and foliage from July 22 to July 25. The total amount of rot on the check before picking was 23.8 per cent.

The following table shows the results of the applications to the different plots:

TABLE VI.—*Results of spraying experiments on nine plots of Niagara grapes at Kendaia, N. Y., in 1907.*

No. of plot.	Number of applications given.	Fungicide used.	Rot.
			<i>Per cent.*</i>
1	8	5-5-50 Bordeaux mixture, and Burgundy mixture No. 2 for last application.	8.8
2	8	4-4-50 Bordeaux mixture, and normal copper acetate and one-half pound of soap for last application.	8.0
3	8	4-4-50 Bordeaux mixture plus 2 pounds of soap, and copper borate No. 1 and 1 pound of soap for last application.	6.2
4	8	Copper borate mixture No. 1 and 1 pound of soap.	10.1
5	8	Burgundy mixture No. 2 and 1 pound of soap.	11.4
6	8	Copper chlorid mixture and 1 pound of soap.	12.8
7		Check, unsprayed.	23.8
8	5	5-5-50 Bordeaux mixture.	6.3
9	5	4-4-50 Bordeaux mixture and soap.	7.2
10	6	Copper borate and 1 pound of soap, and normal copper acetate for last application.	8.3
		Ordinary spraying with Bordeaux mixture as heretofore practiced in the vineyard.	12.072

* Determined by count of rotten berries.

The percentages of rot given were determined by an actual count of the diseased berries found on 2,500 clusters from vines showing the average condition of the plot and by comparing this number with the average number of berries usually produced upon the same number of clusters. (See Pl. I, figs. 1 and 2.)

It will be noted that Bordeaux mixture gave the best results and that five applications proved just about as effective as eight. There was scarcely any difference in the results from the use of the 5-5-50 and the 4-4-50 formulas. There was 2 per cent less rot on plot 3 than on plots 1 and 2, apparently attributable to the addition of the resin soap, but in other cases the benefit from this was not evident.

EXPERIMENTS IN 1908.

The work in New York was continued in the season of 1908 in the same vineyard and on the same vines used in 1907, but the plots were reduced to five-sixths of an acre each.

The following fungicides were used:

Bordeaux mixture, 4-4-50, 4-3-50, and 3-2-50 formulas.

Copper borate mixture No. 3.

Neutral copper acetate solution. This was used chiefly as a nonstaining preparation for final applications.

Self-boiled lime-sulphur, prepared with hot water.

"A" brand concentrated lime-sulphur solution, 1 gallon to 50 gallons of water; also 1 gallon to 75 gallons of water.

Resin-fishoil soap was also added in some cases, as indicated in the tables which follow.

The spraying was done, as in the preceding season, with a gasoline-engine outfit. Stationary nozzles were used for the earlier applica-



FIG. 1.—PORTION OF A NIAGARA VINE WITH THE LEAVES REMOVED, SHOWING SPRAYED FRUIT, KENDAIA, N. Y., 1907.



FIG. 2.—PORTION OF AN UNSPRAYED NIAGARA VINE WITH THE LEAVES REMOVED, FROM CHECK PLOT, KENDAIA, N. Y., 1907.

tions, and three fixed nozzles and trailers with two nozzles each directed by hand were used for the fifth and sixth applications. Plot 7 was a check and received no treatment.

The following table shows the treatment given each of the plots:

TABLE VII.—Treatment given ten plots at Kendaia, N. Y., in 1908.

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
June 1.....	4-4-50 Bordeaux mixture.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 2.....	do.....	Berries one-half grown.
August.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 2.

June 1.....	4-3-50 Bordeaux mixture.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 23.....	do.....	Berries one-half grown.
August 12.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 3.

June 1.....	4-2-50 Bordeaux mixture.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 23.....	do.....	Berries one-half grown.
August 12.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 4.

June 1.....	3-2-50 Bordeaux mixture.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 23.....	do.....	Berries one-half grown.
August 12.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 5.

June 1.....	4-2-50 Bordeaux mixture, with 2 pounds of soap.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 23.....	4-2-50 Bordeaux mixture.....	Berries one-half grown.
August 12.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 6.

June 1.....	3-2-50 Bordeaux mixture, with 2 pounds of soap.....	Shoots 10 inches to 1 foot long.
June 12.....	do.....	Just beginning to bloom.
June 26.....	do.....	Through blooming.
July 8.....	do.....	Berries one-third grown.
July 23.....	3-2-50 Bordeaux mixture.....	Berries one-half grown.
August 12.....	Neutral copper acetate.....	Berries nearly grown.

PLOT 8.

June 12.....	4-3-50 Bordeaux mixture.....	Just beginning to bloom.
June 26.....	Copper borate No. 3, with 1 pound of soap.....	Through blooming.
July 9.....	do.....	Berries one-third grown.
July 23.....	Copper borate.....	Berries one-half grown.
August 12.....	do.....	Berries nearly grown.

TABLE VII.—*Treatment given ten plots at Kendaia, N. Y., in 1908—Continued.*

PLOT 9.

Date of spraying.	Fungicide used.	Stage of growth.
June 12.....	4-3-50 Bordeaux mixture.....	Just beginning to bloom.
June 26.....	Neutral copper acetate.....	Through blooming.
July 9.....	do.....	Berries one-third grown.
July 23.....	do.....	Berries one-half grown.
August 12.....	do.....	Berries nearly grown.

PLOT 10.

June 12.....	4-3-50 Bordeaux mixture.....	Just beginning to bloom.
June 26.....	Self-boiled lime-sulphur No. 1, 8-15-50.....	Through blooming.
July 9.....	do.....	Berries one-third grown.
July 23.....	Self-boiled lime-sulphur No. 2, 10-15-50.....	Berries one-half grown.
August 12.....	"A" brand lime-sulphur No. 2, 1 gallon to 75 gallons of water.	Berries nearly grown.

PLOT 11.

June 12.....	4-3-50 Bordeaux mixture.....	Just beginning to bloom.
June 26.....	"A" brand lime-sulphur No. 1, 1 gallon to 50 gallons of water.	Through blooming.
July 9.....	do.....	Berries one-third grown.
July 23.....	do.....	Berries one-half grown.
August 12.....	"A" brand lime-sulphur No. 2, 1 gallon to 75 gallons of water.	Berries nearly grown.

The plot which had been used as a check in 1907 was sprayed this season. The first signs of disease were noted on June 25, when spots caused by the black-rot fungus began to appear on the leaves.

The following table shows the results of the treatment of the different plots:

TABLE VIII.—*Results of spraying experiments on ten plots of Niagara grapes at Kendaia, N. Y., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.	Yield of select market grapes.	Yield of wine grapes.
			Percent.*	Baskets (4 lb.).	Baskets (20 lb.).
1	6	4-4-50 Bordeaux mixture†.....	1.9	758	157
2	6	4-3-50 Bordeaux mixture.....	1.06	800	131
3	6	4-2-50 Bordeaux mixture.....	.79	610	136½
4	6	3-2-50 Bordeaux mixture.....	.79	608	142½
5	6	4-2-50 Bordeaux mixture and 2 pounds of resin-fishoil soap.....	.49	523	148
6	6	3-2-50 Bordeaux mixture and 2 pounds of resin-fishoil soap.....	1.6	696	160
7		Check, unsprayed.....	17.44	505	112
8	5	4-3-50 Bordeaux mixture, first application only. Following applications, copper borate No. 3, with 1 pound of soap.....	3.48	957	145
9	5	4-3-50 Bordeaux mixture, first application only. Following applications, neutral copper acetate, 1 pound to 50 gallons of water.....	1.01	685	106
10	5	4-3-50 Bordeaux mixture, first application only. Following applications, self-boiled lime-sulphur Nos. 1 and 2.....	1.1	319	150
11	5	4-3-50 Bordeaux mixture, first application only. Following applications, "A" brand lime-sulphur Nos. 1 and 2.....	.37	863	115

* Determined by count of rotten berries.

† Neutral copper acetate used in last spraying on plots 1 to 6, inclusive; also on plot 9.

From this table it will be noted that the smallest percentage of rot, as determined by counting the diseased berries, was upon plot 11, which was sprayed first with 4-3-50 Bordeaux mixture, followed

by three applications of "A" brand concentrated lime-sulphur solution, one gallon to 50 of water, and a final application of 1 gallon of the same material to 75 of water. It was intended to treat this plot throughout the season with the concentrated lime-sulphur solution, but the material was not received in time to be used for the first application. The concentrated lime-sulphur solution, when used at the rate of 1 gallon to 50 of water, caused such severe injury to the foliage that for the final application it was reduced to 1 to 75. Hence, from the facts that this plot was not treated with the concentrated lime-sulphur solution alone, and that the injury to the foliage was so great as to preclude its future use in the same strength, the results do not justify positive conclusions in regard to either the efficiency or the practicability of using this preparation for black-rot. It remains to be determined whether this concentrated lime-sulphur can be diluted sufficiently to avoid injury to the foliage and still retain the necessary fungicidal properties. The plot treated with self-boiled lime-sulphur was also sprayed the first time with Bordeaux mixture, and as the lime-sulphur was made by the use of hot water it also caused some injury to the foliage. The fruit was also rather badly stained by the self-boiled lime-sulphur solutions.

The yield in select market grapes and wine grapes is also given. The yield from the various plots does not always bear a direct relation to the treatment and to the amount of rot present, as the number of vines in the rows varied somewhat and there was also some variation in the vigor and productiveness of the individual vines.

The following is an itemized statement of the expenses connected with the spraying and shows also the returns from the fruit and the gain per acre due to spraying:

Cost of spraying plot 2, five-sixths of an acre, at Kendaia, N. Y., in 1908, returns from plot 2, and returns from the five-sixths-acre unsprayed plot.

Plot No. 2 (sprayed):

800 4-pound baskets, at 12 cents.....	\$96. 00
131 20-pound baskets, at 30 cents.....	39. 30

Total receipts.....	135. 30
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Man, team, and sprayer, each application.....	\$0. 35
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Bluestone, 8 pounds, at 6 cents; lime, 6 pounds, at five-ninths cent.....	. 51½
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One application of Bordeaux mixture, 4-3-50.....	. 86½
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Five applications of Bordeaux mixture, 4-3-50, at 86½ cents.....	4. 32
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Resin-fishoil soap, 3 applications, 12 pounds, at 3½ cents.....	. 42
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One additional application of copper acetate, 2 pounds, at 45 cents, plus 35 cents for application.....	1. 25
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Extra help handling trailers, two applications.....	. 60
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Packing.....	7. 75
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Total, six applications.....	14. 34
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Net receipts.....	\$120. 96
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Net receipts, brought forward.....	\$120. 96
Plot No. 7 (unsprayed):	
505 4-pound baskets, at 12 cents.....	\$60. 60
112 20-pound baskets, at 30 cents.....	33. 60
Total receipts.....	94. 20
Packing.....	16. 00
Net receipts.....	78. 20
Gain from spraying five-sixths of an acre.....	42. 76
Gain per acre at same rate.....	^a 51. 31

WORK IN MICHIGAN.

The principal grape-growing district in Michigan is located in the southwestern part of the State, Paw Paw and Lawton being the principal centers. Until a few years ago fungous diseases had not caused any very serious losses in this region. As is usually the case, it was only after grapes had been grown for a number of years and the vineyards had become quite extensive and numerous that the diseases began to be very serious. For two or three seasons previous to 1907 many of the grape growers suffered severe loss from fungous troubles, especially black-rot. This was apparently due to a combination of circumstances. The fungi causing the diseases had had sufficient time to become thoroughly established and distributed, and under the very favorable climatic conditions which prevailed—excessive heat and moisture during the growing season—proved very destructive.

Most of the growers had had no practical experience in spraying and were hoping that the troubles were of a more or less temporary character, and would perhaps soon pass away. This did not, however, prove to be the case, and during the seasons of 1906 and 1907 the losses were so general and so great that many growers were becoming disheartened. At the time the writers began work in this region few spraying outfits were in use. Some spraying had already been done there under the direction of Professor Taft, of the Michigan Agricultural Experiment Station, but few of the growers had taken up the work. The work of the Bureau of Plant Industry was undertaken in accordance with an understanding with the director of the Michigan Agricultural Experiment Station. The spraying experiments have received continuous personal direction and supervision in every detail throughout each season, and advice and assistance have been given growers whenever desired. The chief purposes of the spraying experiments were to make a comparative test of fungicides and to determine the most efficient methods of treatment under the prevailing climatic and cultural conditions, and incidentally to demon-

^a Six hundred gallons of Bordeaux mixture were used for the six applications on the five-sixths acre. Ordinarily this amount would be sufficient for an acre, and the gain would thus be increased to \$52.62.



FIG. 1.—CARBONIC-ACID-GAS SPRAYER USED IN SPRAYING EXPERIMENTS IN 1907 AND 1908 IN THE VINEYARD OF MRS. EMMA R. SMITH, PAW PAW, MICH.



FIG. 2.—MIXING PLATFORM AND GEARED TRACTION SPRAYER USED IN SPRAYING EXPERIMENTS IN THE VINEYARD OF MR. J. M. TOWERS, PAW PAW, MICH., IN 1908.

strate the practicability of controlling black-rot even in the case of a very severe epidemic.

In 1906, so far as the writers could learn, but six sprayers were in use in the Lawton grape belt. Interest in spraying and confidence in its results have so increased that most of the growers have secured sprayers and are in nearly all cases satisfactorily controlling the black-rot. In the summer of 1908 at least two hundred spraying outfits were found in use, and perhaps there were others of which the writers did not learn. Thirteen different kinds were represented.

EXPERIMENTS IN 1907.

The work of 1907 was commenced in two vineyards in the vicinity of Paw Paw, but in one vineyard, that of Mr. J. M. Towers, it was discontinued on account of partial loss of the crop by frost and insects.

The work in the other vineyard, that of Mrs. Emma R. Smith, was continued throughout the season. This vineyard consisted of Concord vines about 25 years old, trained after the Kniffin system, with the rows running north and south. The fruit the previous season had been almost totally destroyed by rot. Four plots adjoining each other were selected. The three sprayed plots contained about 0.46 acre each, and the check 0.115 acre.

The fungicides used were as follows: 3-50 copper sulphate solution; 5-5-50 Bordeaux mixture; 4-4-50 Bordeaux mixture; 3-3-50 Bordeaux mixture. For the sixth and seventh applications, Burgundy mixture No. 2 was used in order to avoid too much staining of the fruit. The work was done with a carbonic-acid-gas sprayer. (See Pl. II, fig. 1.) The first applications were made with fixed nozzles, and the last three with trailers, the nozzles being directed by hand. In order to determine the percentage of rot present on the different plots, counts of the sound and the diseased grapes were made between September 23 and October 2, 1,000 bunches from each of the sprayed plots and 100 from the check being taken. The check, which received no treatment, was plot 3.

The following table shows the treatment of each plot:

TABLE IX.—Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1907.

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 5.....	3-50 copper sulphate solution.....	Dormant.
June 20.....	3-3-50 Bordeaux mixture.....	Just beginning to blossom.
July 6.....	do.....	Just after blossoming.
July 16.....	do.....	Grapes about size of peas.
July 23.....	3-3-50 Bordeaux mixture, with 2 pounds of soap.	Grapes about one-third grown.
August 2.....	Burgundy mixture No. 2.....	Grapes about one-half grown.
August 15.....	do.....	Grapes about three-fourths grown.

TABLE IX.—*Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1907—Continued.*

PLOT 2.

Date of spraying.	Fungicide used.	Stage of growth.
May 5.....	3-50 copper sulphate solution.....	Dormant.
June 20.....	4-4-50 Bordeaux mixture.....	Just beginning to blossom.
July 6.....	do.....	Just after blossoming.
July 16.....	do.....	Grapes about size of peas.
July 23.....	4-4-50 Bordeaux mixture, with 2 pounds of soap.	Grapes about one-third grown.
August 2.....	Burgundy mixture No. 2.....	Grapes about one-half grown.
August 15.....	do.....	Grapes about three-fourths grown.

PLOT 4.

May 5.....	3-50 copper sulphate solution.....	Dormant.
June 20.....	5-5-50 Bordeaux mixture.....	Just beginning to blossom.
July 6.....	do.....	Just after blossoming.
July 16.....	do.....	Grapes about size of peas.
July 23.....	do.....	Grapes about one-third grown.
August 2.....	Burgundy mixture No. 2.....	Grapes about one-half grown.
August 15.....	do.....	Grapes about three-fourths grown.

The amount of rot on the plots at the close of the season was determined by actual count of the number of sound and affected berries on 1,000 average bunches from each plot, as already stated.

Just across a roadway at the south end of this vineyard was another which was very severely injured by black-rot; in fact, most of the crop was destroyed before the fruit was much over half grown. In order to get some idea of the effect of this apparently serious source of infection upon the portions of the experimental plots nearest to this vineyard, counts were made of the affected grapes at both ends of the rows, those adjoining the neglected vineyard and those farthest from it.

The following table shows the percentage of rot at both ends of each plot, and also the difference between the two ends:

TABLE X.—*Comparison of the amount of rot on the ends of plots adjoining and those farthest from an unsprayed vineyard near Paw Paw, Mich., 1907.*

No. of plot.	Fungicide used.	Rot.		
		South end.*	North end.†	Difference.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Bordeaux mixture, 3-3-50.....	56.4	31.2	25.2
2	Bordeaux mixture, 4-4-50.....	34.9	23.8	11.1
3	Check, no treatment.....	91.7	86.1	5.6
4	Bordeaux mixture, 5-5-50.....	32.7	23.1	9.6

* Adjoining unsprayed vineyard severely affected with black-rot.

† Farthest from unsprayed vineyard.



FIG. 1.—PART OF A CONCORD VINE SPRAYED WITH 5-5-50 BORDEAUX MIXTURE, MRS. SMITH'S VINEYARD, PAW PAW, MICH. PHOTOGRAPHED SEPTEMBER 8, 1907.



FIG. 2.—CONCORD VINE FROM UNSPRAYED AND NEGLECTED VINEYARD IN THE SAME NEIGHBORHOOD AND PHOTOGRAPHED ON THE SAME DAY AS THE VINE SHOWN IN FIGURE 1. THE CROP WAS ENTIRELY DESTROYED AND THE VINE NEARLY DEFOLIATED BY BLACK-ROT.

The average percentage of rot for the four plots is as follows:

TABLE XI.—*Results of spraying experiments on three plots of Concord grapes near Paw Paw, Mich., in 1907.*

No. of plot.	Number of applications.	Fungicide used.	Rot.
			<i>Per cent.*</i>
1	7	3-3-50 Bordeaux mixture †.....	43.7
2	7	4-4-50 Bordeaux mixture.....	28.7
3		Check, unsprayed.....	89.2
4	7	5-5-50 Bordeaux mixture.....	28.3

* Determined by count of rotten berries.

† Soap was used in fifth spraying on plots 1 and 2 and Burgundy mixture No. 2 for the sixth and seventh sprayings on all plots.

Although only 89.2 per cent of the fruit on the unsprayed plot was found by actual count to be destroyed, it was not considered practicable to try to harvest any of it because the expense of separating the small quantity of sound fruit would have been much more than its value. The crop on the unsprayed plot was therefore practically a total loss. It will be noted that there was scarcely any difference in the amount of rot on the plot sprayed with 4-4-50 and on that sprayed with 5-5-50 Bordeaux mixture. Part of a vine from the latter plot and a typical vine from a neighboring neglected vineyard are shown in Plate III. On the neglected vine the fruit was not only completely destroyed, but the plant was defoliated and thus prevented from properly maturing the season's growth of wood.

The following itemized account shows the gain due to spraying on plot 2 (five applications with 4-4-50 Bordeaux mixture and two with Burgundy mixture, or 475 gallons in all, on 0.46 acre) and the corresponding gain per acre estimated upon the same basis:

Receipts and expenditures, plot 2, Paw Paw, Mich., 1907.

2,010 pounds grapes, at \$40 a ton.....	^a \$40. 20
Man and team to spray, 8½ hours, at 35 cents.....	\$3. 06
Man and horse to haul mixture, 8½ hours, at 25 cents.....	2. 19
Two men to carry trailers for last three sprayings, 5½ hours, at 15 cents an hour each.....	1. 58
Two-thirds tube of gas, at \$2.35.....	1. 57
Copper sulphate, 26 pounds, at 8½ cents.....	2. 28
Resin-fishoil soap, 11 pounds, at 3½ cents.....	. 39
Sal soda, 6 pounds, at 3 cents.....	. 18
Total cost of spraying plot, 0.46 acre.....	11. 25
Gain from spraying on 0.46 acre.....	28. 95
Gain per acre at same rate.....	62. 93

^a As no fruit was harvested on the unsprayed plot at Paw Paw, Mich., in 1907, this amount is all attributed to spraying.

EXPERIMENTS IN 1908.

The work in 1908 was carried on in three different vineyards: Mrs. Emma Smith's, as already described; Mr. J. M. Towers's, near Paw Paw; and Mr. C. C. Giddings's vineyard, near Lawton. The work in Mrs. Smith's vineyard was conducted on the same plots used in 1907 and with the same spraying outfit and, as before, trailers with nozzles directed by hand instead of fixed nozzles were used for the last three sprayings. It was found that in order to satisfactorily cover the foliage and fruit at the time of the later applications the nozzles, or part of them at least, must be thus manipulated.

EXPERIMENTS IN MRS. SMITH'S VINEYARD, NEAR PAW PAW, MICH.

The treatment given the different plots in Mrs. Smith's vineyard is shown in the following table. Plot 2 was a check and received no treatment.

TABLE XII.—*Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 19.....	4-4-50 Bordeaux mixture.....	Shoots about 6 inches long.
May 29.....	do.....	Shoots 18 to 24 inches long.
June 2.....	do.....	Shoots 20 to 28 inches long.
June 15.....	do.....	Just after blooming.
June 24.....	do.....	Grapes about the size of peas.
July 3.....	do.....	Grapes about one-half grown.
July 22.....	4-2-50 Bordeaux mixture.....	Grapes about four-fifths grown.

PLOT 3.

May 19.....	4-3-50 Bordeaux mixture.....	Shoots about 6 inches long.
May 29.....	do.....	Shoots 18 to 24 inches long.
June 2.....	do.....	Shoots 20 to 28 inches long.
June 15.....	do.....	Just after blooming.
June 24.....	do.....	Grapes about the size of peas.
July 3.....	do.....	Grapes about one-half grown.
July 6.....	do.....	Grapes about one-half grown.
July 22.....	4-2-50 Bordeaux mixture.....	Grapes about four-fifths grown.

PLOT 4.

May 19.....	4-2-50 Bordeaux mixture.....	Shoots about 6 inches long.
May 29.....	do.....	Shoots 18 to 24 inches long.
June 2.....	do.....	Shoots 20 to 28 inches long.
June 15.....	do.....	Just after blooming.
June 24.....	do.....	Grapes about the size of peas.
July 6.....	do.....	Grapes about one-half grown.
July 22.....	do.....	Grapes about four-fifths grown.

The following table shows the percentage of rot as determined by actual count, as in the preceding season's work:

TABLE XIII.—Results of spraying experiments on three plots of Concord grapes in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1908.

No. of plot.	Number of applications.	Fungicide used.	Rot.
1.....	7	4-4-50 Bordeaux mixture.....	<i>Per cent.</i> 0.197
2.....	7	Check, unsprayed (but sprayed in 1907).....	17.257
3.....	8	4-3-50 Bordeaux mixture.....	.034
4.....	7	4-2-50 Bordeaux mixture.....	.178

The small amount of rot on the check plot was believed to be largely due to the fact that this plot was sprayed in the season of 1907. It would have been better, perhaps, for purposes of comparison, to have used the same check as in 1907. As the amount of rot in a neglected vineyard near by was as great in 1908 as in the previous year, there seems to be no reason to suppose that the rot on this unsprayed plot would not have been about as great also, except for the treatment given it in 1907.

It will be noted that in this experiment the plots sprayed with 4-3-50 Bordeaux mixture showed the least amount of rot. The very small percentage of rot on all the plots illustrates very clearly what may perhaps be called the cumulative effect of spraying. The disease having been largely brought under control the first season can generally be much more easily handled during succeeding seasons.

The following is an itemized account of the work, showing the gain on plot 3, 0.46 acre, which received seven sprayings with 4-3-50 Bordeaux mixture and one with 4-2-50, 500 gallons in all:

Receipts and expenditures, plot 3, Mrs. Smith's vineyard, near Paw Paw, Mich., 1908.

Yield from plot 3, sprayed, 660 8-pound baskets, at 11.66 cents.....	\$76.96	
Receipts per acre at same rate.....		\$167.30
Yield from check plot, 1,134.75 pounds, at \$20.64 a ton.....	11.71	
Receipts per acre at same rate.....		101.83
Gain per acre due to spraying.....		65.47
Man and team to spray, 10 hours, at 35 cents.....	\$3.50	
Man and horse to haul mixture, 10 hours, at 25 cents.....	2.50	
Two men to carry trailers for last four sprayings, 6 hours, at 15 cents an hour each.....	1.80	
Copper sulphate, 40 pounds, at 6½ cents.....	2.70	
Stone lime, 30 pounds, at two-thirds of a cent.....	.20	
Five-sevenths tube of gas, at \$2.35.....	1.68	
Total cost of spraying plot, 0.46 acre.....	12.38	
Cost of spraying 1 acre at same rate.....		26.91
Net gain per acre due to spraying.....		^a 38.56

^a Grapes in same vineyard sprayed five times showed no appreciable difference in amount of rot. Difference in net gain this year was due to extra sprayings and to less loss on check as result of previous treatment (1907).

EXPERIMENTS IN MR. TOWERS'S VINEYARD, NEAR PAW PAW, MICH.

In 1908 spraying experiments were again started in Mr. J. M. Towers's vineyard, near Paw Paw. This vineyard consisted of Concord vines about 8 years old, with the rows running north and south. Nine plots, 0.488 acre each, as nearly uniform in character and condition as possible, were selected. The work was done with the geared traction sprayer shown in Plate II, figure 2. The mixing platform used is also shown in the same figure.

The following fungicides were used: Bordeaux mixture, 4-4-50, 4-3-50, 4-2-50, 5-5-50, 5-4-50, and 5-3-50; also sodium benzoate Bordeaux mixtures Nos. 1 and 2. Six applications were made, as shown in the accompanying tables, the last one consisting of 4-2-50 Bordeaux mixture. Plot 4 was a check and received no treatment.

TABLE XIV.—Treatment given eight plots in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908.

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 20.....	4-4-50 Bordeaux mixture.....	Shoots about 8 inches long.
May 30.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 29.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 2.

May 20.....	4-3-50 Bordeaux mixture.....	Shoots about 8 inches long.
May 30.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 29.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 3.

May 20.....	4-2-50 Bordeaux mixture.....	Shoots about 8 inches long.
May 30.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	do.....	Grapes nearly full grown.

PLOT 5.

May 20.....	5-5-50 Bordeaux mixture.....	Shoots about 8 inches long.
May 30.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 6.

May 20.....	5-4-50 Bordeaux mixture.....	Shoots about 8 inches long.
May 30.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

TABLE XIV.—*Treatment given eight plots in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908—Continued.*

PLOT 7.

Date of spraying.	Fungicide used.	Stage of growth.
May 20.....	5-3-50 Bordeaux mixture.....	Shoots about 8 inches long.
June 1.....	do.....	Shoots 16 to 20 inches long.
June 17.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 13.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 8.

May 20.....	Sodium benzoate Bordeaux mixture No. 2, 1-1-1-50.	Shoots about 8 inches long.
June 1.....	do.....	Shoots 16 to 20 inches long.
June 18.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 14.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 9.

May 20.....	Sodium benzoate Bordeaux mixture No. 1, 2-1-1-50.	Shoots about 8 inches long.
June 1.....	do.....	Shoots 16 to 20 inches long.
June 18.....	do.....	Just after blossoming.
June 30.....	do.....	Grapes the size of peas.
July 14.....	do.....	Grapes about three-fourths grown.
July 25.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

The results of these experiments are shown in the following table:

TABLE XV.—*Results of spraying experiments on eight plots of Concord grapes in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.
			Per cent.*
1.....	6	4-4-50 Bordeaux mixture, first five applications †.....	0.03
2.....	6	4-3-50 Bordeaux mixture, first five applications.....	0.097
3.....	6	4-2-50 Bordeaux mixture.....	0.042
4.....		Check, unsprayed.....	7.36
5.....	6	5-5-50 Bordeaux mixture, first five applications.....	0.051
6.....	6	5-4-50 Bordeaux mixture, first five applications.....	0.07
7.....	6	5-3-50 Bordeaux mixture, first five applications.....	0.064
8.....	6	Sodium benzoate Bordeaux mixture No. 2.....	0.083
9.....	6	Sodium benzoate Bordeaux mixture No. 1.....	0.127

* Determined by count of rotten grapes.

† Bordeaux mixture 4-2-50 was used in sixth spraying on all plots.

The percentages of rot given were obtained by actual count of the rotten grapes on clusters showing the average condition of each plot, as in the other cases. It will be noted that the smallest percentage of rot was found on plot 1, treated with 4-4-50 Bordeaux mixture. The difference in amount of rot, however, on the various plots was so slight in most cases as to give no very decided indication of the comparative value of the different mixtures. The amount of rot on the check plot was also small.

EXPERIMENTS IN MR. GIDDINGS'S VINEYARD, NEAR LAWTON, MICH.

Mr. Giddings's vineyard consisted of Concord vines about 14 years old. Eleven plots of one-third acre each were used in the experiments.

The work was done with a geared traction sprayer, fixed nozzles being used for the first three applications, and trailers, with the nozzles directed by hand, for the last three applications. Plot 5 was a check and was not sprayed.

The following table shows the treatment given each plot:

TABLE XVI.—*Treatment given ten plots in Mr. Giddings's vineyard, near Lawton, Mich., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 21.....	4-4-50 Bordeaux mixture.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots about 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 2.

May 21.....	4-3-50 Bordeaux mixture.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 3.

May 21.....	4-2-50 Bordeaux mixture.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	do.....	Grapes nearly full grown.

PLOT 4.

May 21.....	3-2-50 Bordeaux mixture.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 6.

May 21.....	4-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 7.

May 21.....	3-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

TABLE XVI.—*Treatment given ten plots in Mr. Giddings's vineyard, near Lawton, Mich., in 1908—Continued.*

PLOT 8.

Date of spraying.	Fungicide used.	Stage of growth.
May 21.....	Copper borate mixture No. 2.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 9.

May 21.....	Neutral copper acetate.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 15.....	do.....	Just after blossoming.
June 25.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 10.

May 21.....	Self-boiled lime-sulphur No. 2.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 16.....	do.....	Just after blossoming.
June 26.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

PLOT 11.

May 21.....	"B" brand lime-sulphur, 1 to 50.....	Shoots about 8 inches long.
June 2.....	do.....	Shoots 18 to 24 inches long.
June 16.....	do.....	Just after blossoming.
June 26.....	do.....	Grapes the size of peas.
July 8.....	do.....	Grapes about one-half grown.
July 23.....	4-2-50 Bordeaux mixture.....	Grapes nearly full grown.

As the grape berry-moth was causing considerable loss in Mr. Giddings's vineyard, an arsenical preparation made in accordance with the directions of Prof. A. L. Quaintance, of the Bureau of Entomology, was added to the Bordeaux mixture for the second, third, and fourth applications on all the plots.

The following table shows the results of the treatment of each plot:

TABLE XVII.—*Results of spraying experiments on ten plots of Concord grapes in Mr. Giddings's vineyard, near Lawton, Mich., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.	Yield.
			<i>Per cent.*</i>	<i>Baskets (8 lb.)</i>
1	6	4-4-50 Bordeaux mixture†.....	0.051	187
2	6	4-3-50 Bordeaux mixture.....	0.043	166
3	6	4-2-50 Bordeaux mixture.....	0.15	148
4	6	3-2-50 Bordeaux mixture.....	0.17	120
5		Check, unsprayed.....	28.317	78
6	6	4-2-50 Bordeaux mixture, with 2 pounds of soap.....	0.411	137
7	6	3-2-50 Bordeaux mixture, with 2 pounds of soap.....	0.531	140
8	6	Copper borate mixture No. 2, with 1 pound of soap.....	2.464	125
9	6	Neutral copper acetate, 1 to 50.....	1.088	134
10	6	Self-boiled lime-sulphur No. 2.....	2.413	102
11	6	"B" brand lime-sulphur, 1 to 50.....	3.383	(‡)

* Determined by count of rotten berries.

† Bordeaux mixture 4-2-50 was used for the sixth application on all the plots.

‡ Record wanting.

The percentages of rot were determined by actual count of the diseased berries on 1,000 average bunches, as in the previous cases. The yield in 8-pound baskets is also given for each plot except the last, the record of which is missing. The smallest percentage of rot, as indicated in Table XVII, was found on plot 2, treated with 4-3-50 Bordeaux mixture. The difference between this plot and plot 1, treated with 4-4-50 Bordeaux mixture, is, however, very slight. A portion of a vine from plot 2, showing the condition of the fruit, is illustrated in Plate IV, figure 1, and a portion of a vine from the unsprayed check, showing the general appearance of the fruit, is illustrated in Plate IV, figure 2. The lime-sulphur mixtures produced decidedly less satisfactory results than the Bordeaux mixtures. The self-boiled lime-sulphur, which was prepared with hot water, injured the foliage somewhat, and the "B" brand concentrated solution at the rate of 1 gallon to 50 gallons of water burned the foliage still more seriously, and therefore is unsafe to use in this strength. The results of the treatment with lime-sulphur were so much less satisfactory in this case than in the New York experiments in 1908, in which the first application was made with Bordeaux mixture, that considerable doubt is thrown upon the part played by lime-sulphur in controlling the rot in that case. Further experiments are needed to determine whether lime-sulphur solutions in any form or strength in which they can be used will prove a desirable substitute for Bordeaux mixture. The neutral copper acetate solution, 1 pound to 50 gallons of water, gave better results than any of the other applications except Bordeaux mixture.

The following account shows the expense of spraying and the gain from plot 2, one-third of an acre, sprayed six times with 4-3-50 Bordeaux mixture, 258 gallons being applied, and the estimated gain per acre at the same rate:

Receipts and expenditures, plot 2, Mr. Giddings's vineyard, near Lawton, Mich., 1908.

Yield from plot 2, sprayed, 166 8-pound baskets, at 12½ cents.....	\$20. 75
Yield from check plot, 119 8-pound baskets, at 12½ cents.....	14. 87½
Gain due to spraying.....	5. 87½
Man and team, 2 hours, at 35 cents.....	\$0. 70
Two men to carry trailers for last three sprayings, 1 hour, at 15 cents each.....	. 30
Copper sulphate, 20½ pounds, at 6 cents.....	1. 24
Stone lime, 15½ pounds, at two-thirds of a cent.....	. 10
Total cost of spraying plot, one-third of an acre.....	2. 34
Net gain due to spraying on one-third of an acre.....	3. 53½
Net gain per acre at same rate.....	10. 60½



FIG. 1.—GRAPES ON PLOT SPRAYED WITH 4-3-50 BORDEAUX MIXTURE IN THE VINEYARD OF MR. C. C. GIDDINGS, NEAR LAWTON, MICH. PHOTOGRAPHED SEPTEMBER 12, 1908. THE LOSS FROM BLACK-ROT WAS LESS THAN FIVE ONE-HUNDREDTHS OF ONE PER CENT.



FIG. 2.—GRAPES ON UNSPRAYED CHECK PLOT IN THE SAME VINEYARD AND PHOTOGRAPHED ON THE SAME DAY AS THE VINE SHOWN IN FIGURE 1. MORE THAN TWENTY-EIGHT PER CENT OF THE FRUIT WAS DESTROYED BY BLACK-ROT.

There was an additional loss on the check plot of 15.6 per cent, due to the berry-moth, making a total loss of 43.9 per cent. As this loss was almost entirely prevented on the sprayed plots without additional cost except for the poison used, the above statement does not show all the profit due to spraying.

WORK IN NEW JERSEY.

EXPERIMENTS IN 1908.

In former years the Concord grape was rather extensively grown in New Jersey, especially for the manufacture of grape juice. The black-rot soon became troublesome, owing to some extent, no doubt, to the climatic conditions which favor its development. Some of the earliest experiments in spraying to control the disease in this country were undertaken at Vineland, N. J., by the Department of Agriculture, in 1887. The results obtained were very satisfactory, considering the fact that spraying had only recently been introduced and that mixtures and machines were in a very crude and unsatisfactory state.

In recent years the Concord grape has been largely abandoned in New Jersey and other more disease-resistant varieties introduced. Many of these varieties, however, are not so productive or as well adapted to the manufacture of juice.

At the request of those interested in the industry and in cooperation with the New Jersey Agricultural Experiment Station the Department of Agriculture has undertaken to demonstrate that by proper methods of spraying practiced in connection with better methods of pruning, training, and cultivation, the Concord grape can still be successfully and profitably grown in that region. The part of the work pertaining to pruning, training, and cultivation was undertaken by the Office of Field Investigations in Pomology of the Bureau of Plant Industry and carried out under the immediate direction of Mr. George C. Husmann, Pomologist in Charge of Viticultural Investigations.

A small Concord vineyard, one of the very few still remaining in this region, located on the grounds of the New Jersey Training School for the Feeble Minded, at Vineland, was very kindly placed at the disposal of the writers by Professor Johnstone, superintendent of the school. The total area was about 0.75 acre. Three rows, which were pruned according to different methods, were sprayed for comparison with a single unsprayed check row, which was pruned according to the ordinary system that had been followed in the vineyard. This was a modified Kniffin system. The spraying was done with a hand pump attached to a barrel which was drawn in a cart.

The following table shows the treatment of the vineyard. As rose-bugs are usually very troublesome here, 3 pounds of arsenate of lead

were added to the Bordeaux mixture for the second and third applications.

TABLE XVIII.—*Treatment given a vineyard of Concord grapes at Vineland, N. J., in 1908.*

Date of spraying.	Fungicide used.	Stage of growth.
May 4.....	4-3-50 Bordeaux mixture.....	Shoots 6 to 8 inches long.
May 20.....	4-3-50 Bordeaux mixture, with 3 pounds of arsenate of lead.	Flowers almost ready to open.
June 8.....	do.....	Just passed blooming.
June 26.....	4-3-50 Bordeaux mixture.....	Fruit about one-third grown.
July 27.....	3-1-50 Bordeaux mixture.....	Fruit nearly grown.

The last application, of 3-1-50 Bordeaux mixture, left very little stain on the fruit and showed no signs of injury to the foliage. It gives some promise, therefore, of success as a final application when too much staining of the fruit is objectionable.

The results of the spraying were as follows: Row 1, pruned and trained according to a modified Munson system, produced 347 pounds of sound fruit; row 2, treated the same as row 1, produced 267 pounds of sound fruit. Half of row 2, pruned and trained according to a modified Munson system, produced 157 pounds of sound fruit; the other half, pruned and trained according to the Kniffin system, produced 110 pounds. This appears to show a difference of 47 pounds of fruit apparently attributable to the method of pruning and training. Row 3, which was the check row, received no spraying and was pruned according to the ordinary practice of the neighborhood. This produced only 114 pounds of fruit. It was estimated, however, that half of the loss on this row was due to rose-bugs which destroyed the young fruit immediately after the blossoms fell. The rose-bugs, however, were picked by hand from both the sprayed and the unsprayed rows.

There was practically no loss from black-rot on the sprayed rows, as only occasionally could a diseased berry be found. Comparing each of the sprayed rows with the check row, the following results are obtained:

TABLE XIX.—*Results of spraying and pruning experiments on a vineyard of Concord grapes at Vineland, N. J., in 1908.*

No. of row.	Production.	Total loss.	Loss by rose-bugs.	Loss by black-rot.	
	Pounds.	Pounds.	Pounds.	Pounds.	Per cent.
1 (sprayed).....	347	(No loss.)	(No loss.)	(No loss.)	00.0
3 (check).....	114	233	116½	116½	31.3
2 (sprayed).....	267	(No loss.)	(No loss.)	(No loss.)	00.0
3 (check).....	114	153	76½	76½	31.9

The average of the crops from the two sprayed rows is 307 pounds. The crop on the check row being only 114 pounds shows a loss of 193 pounds; allowing one-half of this for loss by rose-bugs, the loss of



FIG. 1.—PORTION OF A VINE SPRAYED WITH BORDEAUX MIXTURE, VINELAND, N. J., 1908, SHOWING PRACTICALLY NO LOSS FROM BLACK-ROT.



FIG. 2.—PORTION OF AN UNSPRAYED CHECK ROW IN THE SAME VINEYARD AS THE VINE SHOWN IN FIGURE 1, 1908, SHOWING 31 PER CENT OF LOSS FROM BLACK-ROT AND ABOUT THE SAME AMOUNT OF LOSS FROM ROSE-BUGS.

96.5 pounds, or 31.4 per cent, was caused by black-rot. In other words, the sprayed rows show practically no loss from rot and the unsprayed check row shows over 31 per cent, or a total loss of over 62 per cent, when the injury from rose-bugs, which was also largely prevented by the spraying, is added.

A portion of a sprayed vine showing the condition of the fruit is illustrated in Plate V, figure 1, and a part of an unsprayed vine from the check row is shown in figure 2 of the same plate.

COMPARISON OF RESULTS OBTAINED WITH DIFFERENT FORMULAS OF BORDEAUX MIXTURE.

The following table gives in condensed form the results of the tests of different formulas of Bordeaux mixture:

TABLE XX.—*Comparison of results secured from use of different formulas of Bordeaux mixture.*

PENNSYLVANIA.

Formula used.	Year.	Number of appli- cations.	Results.
			<i>Yield, bushels.</i>
4-4-50 Bordeaux mixture.....	1908	3	554
4-3-50 Bordeaux mixture.....	1908	3	479

NEW YORK.

			<i>Rot, per cent.</i>
4-4-50 Bordeaux mixture, with soap.....	1907	7	6.6
5-5-50 Bordeaux mixture.....	1907	5	6.3
4-4-50 Bordeaux mixture, with soap.....	1907	5	7.2
4-2-50 Bordeaux mixture, with soap.....	1908	6	0.49
4-2-50 Bordeaux mixture.....	1908	6	0.79
3-2-50 Bordeaux mixture.....	1908	6	0.79
4-3-50 Bordeaux mixture.....	1908	6	1.06
4-4-50 Bordeaux mixture.....	1908	6	1.9

MICHIGAN (MRS. SMITH'S).

5-5-50 Bordeaux mixture.....	1907	7	28.3
4-4-50 Bordeaux mixture, with soap.....	1907	7	28.7
4-3-50 Bordeaux mixture.....	1908	7	0.034
4-2-50 Bordeaux mixture.....	1908	7	0.178
4-4-50 Bordeaux mixture.....	1908	7	0.197

MICHIGAN (MR. TOWERS'S).

4-4-50 Bordeaux mixture.....	1908	6	0.03
4-2-50 Bordeaux mixture.....	1908	6	0.042
5-5-50 Bordeaux mixture.....	1908	6	0.051
5-3-50 Bordeaux mixture.....	1908	6	0.064
Do.....	1908	6	0.097

MICHIGAN (MR. GIDDINGS'S).

4-3-50 Bordeaux mixture.....	1908	6	0.043
4-4-50 Bordeaux mixture.....	1908	6	0.051
4-2-50 Bordeaux mixture.....	1908	6	0.15
3-2-50 Bordeaux mixture.....	1908	6	0.17
4-2-50 Bordeaux mixture, with soap.....	1908	6	0.41

From a comparison of these tables it may perhaps be justifiable to draw some tentative conclusions in regard to the best formula for Bordeaux mixture as a preventive of black-rot.

In the cases in which the 4-4-50 formula was used in comparison with the 5-5-50 formula, the former proved best in New York in 1907 and in Michigan in 1908, and gave almost equally satisfactory results in Michigan in 1907, there being only four-tenths of 1 per cent difference shown.

In the cases in which the 4-3-50 formula was compared with the 4-4-50 formula, the former gave slightly better results in New York in 1908 and decidedly better results in Michigan in Mrs. Smith's vineyard in 1908, and slightly better results in Michigan in Mr. Giddings's vineyard in 1908. There was very little difference in the results in the other cases in which these formulas were used—Pennsylvania in 1908 and Michigan, Mr. Towers's vineyard, in 1908. The 4-3-50 mixture gave entirely satisfactory results in the New Jersey experiment also.

The 4-2-50 formula gave better results than either the 4-4-50 or the 4-3-50 formula in one case, New York, 1908, and was second best in two other experiments, Michigan, Mrs. Smith's vineyard, 1908, and Mr. Towers's vineyard, 1908.

The 3-2-50 formula did not stand above third place in any of the cases in which it was used.

The 4-4-50 formula is found at the head of the table in three cases, and the 4-3-50 in two cases. The writers believe, however, that the 4-3-50 formula, which was not used in all the experiments in comparison with the 4-4-50, will prove the best for general use, in view of all the circumstances and the results thus far obtained.

GENERAL CONCLUSIONS.

When fresh stone lime is used in the preparation of Bordeaux mixture, as should always be done if possible, 3 pounds of lime will be ample to more than neutralize 4 pounds of copper sulphate, and since according to recent investigations already mentioned a great excess of lime is likely to prove detrimental rather than beneficial this quantity is preferable.

Of the mixtures other than Bordeaux which have been used, none has shown sufficiently good results to give promise of being a profitable substitute for it. Of such mixtures, neutral copper acetate gave the best results in Michigan, Mr. Giddings's vineyard, 1908, and also in New York in 1908. Neutral copper acetate solution also promises to be one of the most valuable fungicides for use as a final application when there is need of a nonstaining preparation. It will, however,

be desirable to compare this carefully with the ammoniacal solution of copper carbonate to determine more accurately their relative value.

In nearly all of their experiments the writers have tried to determine the value of adding an adhesive preparation, or "sticker" as it is sometimes called. Resin-fishoil soap has been used for this purpose. The percentage of rot on the plots on which this was used has never been sufficiently reduced to justify the additional expense and trouble involved.

A study of the tables giving the results of the spraying experiments will show that where different numbers of applications were made in the same series, five applications made at the proper times gave nearly or quite as satisfactory results as six, seven, or even eight. Unless a vineyard has been neglected or rot has destroyed the greater part of the crop the preceding season, an application before the buds open, judging from the experiments of the writers, is not profitable; neither does spraying when the shoots are less than 6 inches long seem to materially improve the results.

Different forms of spraying outfits have been used in these experiments, as has already been pointed out. It is impossible to state that any one kind is best, as the conditions under which the work is to be done and other circumstances must always be taken into consideration. The writers have done very satisfactory work with geared traction outfits, with carbonic-acid-gas sprayers, and with gasoline power sprayers. It has been found necessary in some cases to modify the outfits somewhat, especially the arrangement and the number of the stationary nozzles.

In cases where the rot is severe and the season favorable for its development, in order to secure the most satisfactory results it is necessary to use trailers or long leads of hose which can be handled by persons walking behind the machine and directing the nozzles so as to thoroughly cover the fruit and foliage. This can not be done satisfactorily by stationary nozzles when the foliage is very heavy.

SUMMARY.

Bordeaux mixture prepared according to the 4-3-50 formula has been found to be as effective in preventing black-rot as the formulas in which larger quantities of copper sulphate and lime are used.

Five or six applications, beginning when the shoots were 8 inches to 1 foot long, gave generally as good results as when one or two additional earlier applications were made, showing apparently that no particular benefit is derived from dormant applications or from applications made when the shoots are less than 8 inches long.

Where unsprayed grapes were a total loss from black-rot in 1907 the rot on the sprayed plots was reduced to 28.3 per cent. The next

season, 1908, when the rot was almost equally bad on unsprayed vineyards, the rot on the same sprayed plots was reduced to much less than 1 per cent, showing apparently the great cumulative effect of treatment for two seasons.

The gain due to spraying varied in the different vineyards, according to the severity of the rot, the number of sprayings, the productiveness of the vines, and the cost of materials and labor, from \$10.60 to \$62.30 per acre.

The experiments have shown the necessity of covering the vines thoroughly with a fine spray of properly prepared Bordeaux mixture. When the black-rot is serious or the foliage is very heavy it is necessary to use trailers and have the nozzles directed by hand, as fixed nozzles will not properly cover the foliage and fruit.

The tests of various lime-sulphur preparations have not yet been sufficient to determine their value as a preventive of black-rot.

Neutral copper acetate, 1 pound to 50 gallons of water, has been found to be the best nonstaining preparation tested in these experiments for final applications.

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B. T. GALLOWAY, *Chief of Bureau.*

A STUDY OF DIVERSITY IN EGYPTIAN COTTON.

BY

O. F. COOK, ARGYLE McLACHLAN, AND
ROWLAND M. MEADE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 8, 1909.

SIR: I have the honor to transmit herewith a paper entitled "A Study of Diversity in Egyptian Cotton," by Messrs. O. F. Cook, Argyle McLachlan, and Rowland M. Meade, of this Bureau, and recommend its publication as Bulletin No. 156 of the Bureau series.

This Bureau has conducted experiments with Egyptian cotton at Yuma, Ariz., for several years past, under the direction of Mr. T. H. Kearney. The results have been increasingly favorable. In the season of 1907 the cotton was so good, both in yield and in quality, as to justify our calling attention to this crop in Bulletin No. 128 of this Bureau as likely to prove suited to cultivation in the irrigated districts of Arizona and adjacent States.

In the season of 1908 the results were somewhat less favorable, though by no means discouraging. The planting of the cotton in other localities in Arizona and southern California showed that the acclimatization, which appeared to be well advanced at Yuma last year, is not sufficiently complete to insure normal behavior of the plants in other places. And even at Yuma the cotton of this season showed an appreciable deterioration, affecting the yield as well as the length and uniformity of the fiber.

As soon as these unfavorable tendencies became apparent Mr. Kearney asked that they be made the subject of special study to ascertain their nature and causes. Mr. Cook and his assistants were assigned to this work because they had become familiar with the behavior of cotton during the period of acclimatization, in connection with the weevil-resistant Central American cottons recently introduced into Texas. The present report contains the results of their investigations. It shows that the deterioration can be traced to the existence of several forms of diversity among the plants, and that cultural practices as well as factors of breeding and acclimatization must be taken into account in order to secure the necessary uniformity of the product.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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A STUDY OF DIVERSITY IN EGYPTIAN COTTON.

INTRODUCTION.

The diversity found in the Egyptian cotton in Arizona appears to be of four different kinds, evidently arising from different physiological factors. Precautions which may tend to avoid one kind of diversity will not be fully effective unless other factors are taken into account at the same time. Methods of acclimatization, breeding, and culture have all to be adapted to the special needs of the case if the full possibilities of the new crop are to be definitely ascertained.

The first and most striking kind of diversity is due to hybridization. The cross-fertilizing insects are much more abundant and active in our Southwestern States than in any other cotton-growing region thus far investigated. This will render it impossible to maintain a culture of pure Egyptian or other high-grade cotton unless all other kinds of cotton are excluded from the localities in which superior stocks are planted. Though the lint of the hybrid plants is often superior to that of the pure Egyptian plants, it is sufficiently different to interfere with the commercial uniformity of the product.

The second kind of diversity that affects the Egyptian cotton is evidently due to incomplete acclimatization. As with other types of cotton, transfer to new conditions induces great variation, not only in the habits of growth and other vegetative characters of the plants, but also in fertility and in the abundance and length of the lint. This form of diversity is to be eliminated by the selection each year of the plants that approach most nearly to the normal form of the variety, are the most fertile, and have the best lint.

The third kind of diversity is more directly connected with differences in the physical environment which cause or call forth differences in the individual plants. It is shown most strikingly in comparing the behavior of the plants in the different localities, but includes also some of the differences that occur in the same locality or in different parts of the same field. This form of diversity is familiar in all branches of agriculture, but is greater with a newly introduced variety, and may be expected to decrease as a better adjustment to the new conditions is attained. The second kind of diversity represents incomplete acclimatization, while the third kind is more closely connected with the phenomenon of accommodation.

The fourth kind of diversity is shown in the different parts of the same plant and is often very pronounced, especially in the characters of the lint. If the plants become too luxuriant, fruiting is deferred till late in the season or the early bolls remain poorly developed and produce a very weak fiber. To avoid this form of diversity, a proper relation has to be established between the habits of growth of the plants and the methods of culture and irrigation. Sudden changes in the rate of growth are particularly to be avoided as tending to produce fluctuations in the fertility of the plants and in the commercial quality of the lint.

The principal reason why diversity has such serious effects upon the yield of lint is found in the habit of the cotton plant to produce two types of branches which are quite distinct in form and function. Slight differences of external conditions which might have very little direct effect upon the size and vigor of the plant are able to induce relatively great differences in the yield by inducing a preponderance of the sterile, vegetative form of branches over the fertile form.

EGYPTIAN COTTON RELATED TO AMERICAN VARIETIES.

The cultivated varieties of cotton appear to fall into two series. Varieties native in America find their nearest relatives in other New World varieties, and all appear to be widely distinct from the indigenous species of Asia and Africa. Though very different from the Upland varieties of the United States, the Egyptian cotton and the Sea Island cottons are also native of tropical America and are not so fundamentally different from the Upland cottons as is often supposed.

No varieties have as yet been discovered which are exactly intermediate between the Egyptian and the Upland types, but many of the Central American and West Indian varieties which are obviously related to our Upland cottons show some of the characteristics of the Egyptian and the Sea Island series. At the same time it has been found that the West Indian and Central American relatives of the Sea Island and Egyptian cottons show many Upland characters. Only a little additional evidence is needed to prove that the native American types of cotton form a continuous series, without any larger breaks than those which serve to separate the very numerous local varieties still kept in cultivation among the agricultural Indians of tropical America. The results of the present study of diversity in Egyptian cotton tend to emphasize the relationships of the American varieties and make it evident that the Egyptian cottons have the same wide range of variation that other American cottons have been known to display.

NATURE OF DIVERSITIES AROUSED BY NEW CONDITIONS.

Transfer to new conditions has the effect of bringing back into expression many ancestral characters which do not appear when a variety is growing under conditions to which it is thoroughly accustomed. This tendency toward increased diversity under new conditions is not confined to cotton, but is widely prevalent among cultivated varieties of other plants. It is practically recognized in the fact, well-known among gardeners and florists, that the highest grade of seed of many varieties is produced only in the locality where the variety was developed. Everywhere else it appears to deteriorate by reason of the diversity that shows itself in the second or third generations, if not in the first.

The usual statement that the deterioration is due to unfavorable conditions is not a sufficient explanation of the diversity which often constitutes the deterioration. It is not reasonable to suppose that one set of new conditions can be directly responsible for the large number of differences that often appear. It is easier to believe that the new conditions are indirectly responsible for the diversity and that they bring it about by disturbing the heredity of the plants; that is, they disturb the internal adjustments which control the development of the individual plants and thus allow each of the individuals to develop in a different way, as they often appear to do. Even when a whole planting of a newly imported stock appears to change over to a new type quite different from the normal form in the previous environment a notable amount of individual difference is usually to be found, and this diversity may even appear to increase for two or three generations, or until the variety becomes readjusted to normal behavior under the new conditions.

That the new conditions are not directly responsible for the diverse characters that appear is also shown by the fact that different sets of new conditions often call forth closely similar examples of diversity. Different plantings of the same stock bring out the same series of diversities, and there is even a general correspondence between the ranges of diversity shown by different stocks. Features supposed to characterize only one variety are found to crop out in many related varieties. It becomes evident that the diversities, though they may be very extensive and very complex, are not entirely indefinite or at random but fall into parallel and related series, so that it is possible to think of the many newly aroused diversities as representing not new characters but returns to old characters, as though the new conditions had caused the plants to wander from their usual path of development and thus to fail to reach their normal goal.

DIVERSITY OF RECOGNIZED EGYPTIAN VARIETIES.

Varieties of Egyptian cotton seem to have been known chiefly by differences in the fiber rather than by differences in the plants. Though the Egyptian type of cotton as a whole seems to have a range of variation parallel to that of our Upland series of varieties, only a few varietal forms have been separated and given distinctive names. Much less attention has been given to differences in the vegetative characters of the plants than with our Upland varieties. The larger size and the more open habit of growth make it more difficult to become familiar with the vegetative differences in the Egyptian cotton than in the Upland cottons. In the smaller and more compact Upland plants individual differences can be seen and compared much more readily and are of the greatest assistance in acclimatization and breeding.

Unless we know the normal form of the plants as they grow under accustomed conditions we can not be sure that the selection that we apply to them is really calculated to favor the most prompt adjustment to the new conditions. In the absence of sufficiently definite knowledge of this kind, fertility and the characters of the lint are the only standards of selection that can be applied. If we select too narrowly we may preserve variant forms rather than the usual type of the variety, while if we retain good plants of many forms the intermingling of these may tend to prolong the condition of diversity.

A study of the range of diversity of the newly introduced Egyptian cottons was made for the double purpose of being able to judge of the extent of acclimatization and of securing a better basis for distinguishing hybrids. The same schedule or set of characters was used as a guide in the study of diversity in the plots raised from imported seed as was later employed in the study of the acclimatized stocks and the hybrids. The characters which received the most attention are indicated in greater detail in the latter part of the present report, where the hybrids are considered. The general plan of working with a series of the more definitely contrasted characters in mind had already been developed in the study of hybrids from the standpoint of the Upland types of cotton in Texas, and the work in Arizona was greatly facilitated by this preliminary practice.

It is not improbable, of course, that this method of procedure may have led us to overlook some forms of diversity that did not come within the range of our schedule of characters. On the other hand, it may be claimed that our work was able to give us more definite conclusions because the results of the study of diversity took a form which adapted them directly to the purposes of our inquiry.

DIVERSITY OF NEWLY INTRODUCED JANNOVITCH COTTON.

Fortunately for the purposes of the present study, plots of two of the most prominent commercial varieties of Egyptian cotton were grown this year at Yuma, Ariz., from newly imported seed obtained by Mr. David Fairchild, through the kindness of Mr. George P. Foaden, Secretary-General of the Khedivial Agricultural Society of Cairo, Egypt. A study of these plants has enabled us to gain an idea of the range of diversity which the Egyptian cottons are able to show before they have had an opportunity to be hybridized with Upland cottons in the United States. Doubtless these plants are more diverse than the same varieties would be under accustomed conditions in Egypt. A similar increase of diversity is known to take place in Mexican and Central American varieties of cotton when planted for the first time in Texas.

It has not been possible to find any single character in which the newly introduced Jannovitch cotton is uniform and constant. The habit of growth, the form and color of the leaves and flowers, the size and shape of the bolls, the fuzzy coating of the seed, and the length, strength, abundance, and color of the lint are all shown to be capable of pronounced variation.

Some of the plants had fertile branches near the ground, while on others all the lower branches were transformed into sterile "limbs" and produced no bolls or were only beginning to do so at the end of the season, near the top of the plant. The color and texture of the foliage vary considerably, some of the plants having a much lighter and more yellowish shade of green than the others. The lobes of the leaves are much longer and narrower on some plants than on others.

The flowers show a wide range of color. The prevailing tint is a rather deep, almost orange-yellow, though many have a lighter lemon shade and a few are pale and creamy, scarcely darker than those of Upland varieties and with the dark basal spots on the petals faint and broken, much as in hybrids with Upland cottons. And yet these pale-flowered plants showed no other approach to Upland characters.

The bolls vary in size and shape, some being rather short and rounded and others long and pointed and with the sides more or less flattened. The end may be drawn out into a distinct beak or may be abruptly shortened. The surface varies from a very dark blackish green to a much lighter green, more like that of the leaves and bracts. The oil glands which are scattered over the surface of the bolls also vary much in the different plants. Some bolls have very numerous small glands and others larger glands standing farther apart. The number of locks or compartments of the bolls varies from two to five. Two-locked bolls are not uncommon, some being present on nearly every plant. The great majority of the bolls have three locks, many

of the plants having no bolls with four locks and many only a few. Five-locked bolls were found on one plant, although they were not supposed to occur at all in Egyptian cotton.

Some plants have the seeds almost completely naked, while others have them more than half covered with dense, closely adherent fuzz. The color of the fuzz also varies between a light seal-brown and a rather bright bluish green. Both the brown and the green fuzz may be combined with somewhat more woolly, whitish fuzz, especially at the upper or more rounded end of the seed. Seeds completely covered with white fuzz were also found in the original stock of seed imported from Egypt. These variations of the fuzz are of special interest in view of the fact that Egyptian cotton is sometimes supposed to have only smooth seeds, whereas completely naked seeds are very rarely found.

The lint varies in the different plants as much as any other feature. Not only the length, but the abundance, strength, fineness, and color of the fiber are subject to change. Some of the short lint is less than half the length of the longest; some of the seeds produce only half as much lint as others; some have the very strong lint for which Egyptian cotton is noted, while others have the lint so weak as to be almost worthless. Some have very fine, silky lint, while others have the fiber relatively coarse, coarser, in fact, than some of our Upland cottons. Some plants have lint as white as Upland cotton, while others show the distinctly pale brownish cast which is reckoned as one of the special characteristics of Egyptian cottons.

In addition to these more obvious differences, similar variations may be found in other details. Most of the plants have the calyx completely truncate or with scarcely appreciable, broadly rounded lobes, but some plants have the lobes more distinct and prominent. There is usually a rim of rather sparse hairs above the internal nectary of the calyx, though the hairs are sometimes lacking. The stigmas are usually very long and project far beyond the stamens, but in rare cases the stigmas are short and scarcely emerge from among the stamens, as in some of our Central American types. The stamens also vary considerably in number and arrangement. Instead of the usual compact mass of stamens arranged in five double rows there may be only a few stamens, and these may be widely separated in two groups or bands, one at the end of the staminal tube and the other near the middle, with an open space between. Three plants were found in the block of newly imported Jannovitch cotton which were well outside the range of diversity for the variety in having small white flowers, with petal spots pale or lacking altogether. These plants will be considered later in connection with similar aberrant plants which occurred in imported Mit Afifi cotton.

DIVERSITY OF NEWLY INTRODUCED MIT AFIFI COTTON.

Newly introduced Mit Afifi cotton, like the Jannovitch, showed a considerable range of diversity at Yuma in 1908, not only in the habits of growth, but more especially in the features of flowers, bolls, and lint. The plants are distinctly shorter on the average than those of the adjacent Jannovitch plot, but the diversity inside the varieties is too great to make it possible to distinguish any other obvious general difference between them. In other words, the characters of most of the Mit Afifi plants are not sufficiently distinctive to separate them from the Jannovitch if the two varieties were mixed together. Nevertheless the diversity of the Mit Afifi cotton seems broader than that of the Jannovitch, so that some of the plants might be recognized by distinctive features not shared with members of the Jannovitch series.

The habits of growth appear less diverse than several other characters. The plants are usually erect and from 6 to 8 feet tall. Some are prostrate, but these have merely broken over by the weight of the limbs and continue growing in a prostrate position. The prostrate plants are as long as those that have remained erect. Growing in the shade of the others the prostrate plants have large, dark green, crumpled leaves with broadly rounded lobes. The leaves of the upright plants have lighter shades of green; they are also more sharply lobed and smaller, with more even surfaces. The widths and lengths of the lobes differ somewhat among the upright plants.

The main axis is not well differentiated from the numerous long, upright basal limbs, which equal it in height. Usually the plants have three or four large limbs that rise from the lowest nodes, but some put out many more, and sometimes from nodes as high as a foot above the soil.

All fruiting branches are, as a rule, borne above the middle of the plant. There is only a slight difference between plants as to the height at which these branches begin to appear. In cases where the fruiting branches are from the lower nodes they are weak growths and retain very few bolls. Bolls retained on the lower branches are also undersized, as if they had been poorly nourished.

All plants agree in being practically devoid of hairs on all their parts. The veins of leaves and of bracts occasionally bear a few short, stellate hairs, but hairiness may be said to be lacking in Mit Afifi cotton.

The bracts differ widely. The usual type is rather long and slender, with short teeth. The three apical teeth grow from a median prolongation of the bract and stand apart from those on either side. The number of the teeth commonly varies from seven to eleven. Bracts can

be found, however, which depart from all these typical characters. Thus there are broad, coarse bracts with teeth more pronounced and without the usual specialization of the apical teeth. Other bracts have the teeth notably reduced in size and in number. Some of the bracts become red when old or on exposure to the sun, but most of them remain light green.

Three features of Mit Afifi bracts appear to be nearly constant. The mature bracts have a stiff, brittle texture. The young bracts are not so stiff, but are smooth and shining. The second constant feature is the close appression of the bract to the bud and boll. The bracts of Egyptian cottons, unlike those of Upland varieties, have no distinct bulging at the base, no external indication of the place where the bract separates from the enlarged extremity of the peduncle. Instead of being deeply notched at the base, with the corners extending back on either side, as in Upland cotton, the base of the bract is more nearly a straight line, making the general shape of the bract triangular rather than cordate.

The calyx is normally longer than in Upland cotton, and has a nearly even, truncate margin, though variations are frequently met with. The calyx may be considerably shortened or may show broadly rounded and irregular lobes. Sometimes the calyx has a large lobe on one side, while the other side is correspondingly abbreviated. It has been observed by Mr. F. L. Lewton that the calyx of the Egyptian cottons does not fit so closely about the bases of the petals as in the Upland cotton. This permits a large species of carpenter bees to steal nectar from the Egyptian cottons without going inside the flowers.

The internal nectary of the calyx is usually accompanied by a rather indistinct band of hairs along its upper margin. The length and abundance of these hairs differ on different plants, while on a few the hairs are altogether wanting. Upland cottons have a very distinct ring of hairs surmounting the internal nectary, in some cases quite prominent.

The color of the flowers of Mit Afifi cotton is a bright lemon-yellow, with dark reddish purple spots at the base of the petals. Partial abortion or failure of flowers to open is frequent in Mit Afifi plants, though not found in Jannovitch. In the diversity of its flower characters the Mit Afifi cotton shows greater range than the Jannovitch. Few of the flowers are as deep a lemon-yellow as the deepest of the Jannovitch flowers and many are paler than the palest Jannovitch. The pale flowers of the Mit Afifi plants have about the same shade of color as the pale-colored flowers of Upland hybrids. The petal spots show considerable range also, from large or dark spots to small and light. One plant bearing deep yellow flowers had petal spots so

faint as to be barely distinguishable. The shade of the petals and the depth of the color of the spot are not correlated in any way. The shade of purple in the petal spots is the same in the three imported stocks of Egyptian cotton growing at Yuma.

The petals of the Mit Afifi cotton usually appear somewhat shorter and smaller than those of the Jannovitch. The average length of the petals is about 2 inches, while the range is from $1\frac{1}{2}$ to $2\frac{1}{4}$ inches. The style may protrude more than half an inch beyond the staminal tube or it may barely extend above the stamens. Stable Upland varieties do not show this irregularity, but as a rule this part of the pistil is consistently short. In Mit Afifi cotton grown for several years in Arizona the style is more uniformly short and thicker than in plants from newly introduced seed. No variation was detected in the color of the Mit Afifi pollen, which is a golden yellow.

One of the most distinctive flower features of Mit Afifi, as well as of Jannovitch cotton, is the arrangement of the stamens in five double series, which is apparent as one looks into the open flower. This appearance is due partly to the short staminal filaments. It occurs also in the Asiatic cottons which have similar short stamens. Opposed rows of stamens rising from each of the five ridges of the staminal tube lean toward each other to form the double series. This is not a constant feature in the Mit Afifi cotton growing at Yuma; some of the flowers have no indication of the arrangement of the stamens, though their stamens may be as short as in other flowers which have the feature well marked. In flowers of Upland cotton, where the filaments are much longer than in Egyptian, this arrangement of the stamens is never apparent.

Perhaps the greatest diversity in the imported Mit Afifi cotton appears in the shapes and sizes of bolls. The most common type is a well-filled boll $1\frac{1}{2}$ inches long by 1 inch in diameter, with a rather blunt point. Some plants bear long, narrow, pointed bolls, while the bluntness of the usual type is occasionally exceeded by the very short, nearly spherical bolls found on some of the plants. The range of these boll characters is greater than in imported Jannovitch cotton, though the Mit Afifi bolls average shorter and thicker than those of the Jannovitch. The bolls are of a dark, shining green and are pitted with large black oil glands which lie close to the surface and deepen the dark green color. In rare cases the bolls are lighter green, with dull surfaces or with the oil glands somewhat more deeply buried under a layer of green tissue.

The predominant number of locks or carpels is three. The most frequent deviation from this is to the two-locked boll. Nine plants out of ten on which a census of the number of bolls and their locks was taken bore two-locked bolls, one plant having as high as 43

per cent of the two-locked bolls. A few of these had also one or two four-locked bolls, but it seems a general rule that when two-locked bolls are borne in any considerable numbers (15 per cent or more) it is to the exclusion of four-locked bolls, and vice versa. One plant had 33 per cent of four-locked bolls and no two-locked bolls. On the other hand, when the bolls of a plant are nearly all three-locked, both two-locked and four-locked bolls may be found in small numbers. The plant having the high percentage of two-locked bolls grew in the same row and next to the individual with the abundance of four-locked bolls. Diversity in this particular is evidently inherent in the plant rather than dependent upon differences in soil and moisture.

The lint varies to nearly as great an extent as the boll. The usual color is light buff. This is more constantly the case than in Jannovitch cotton, but many shades of buff are found; a few plants have the lint nearly white. The texture also varies from silky to harsh, the latter approaching the short-staple Uplands. The range of length is from 1 inch to $1\frac{1}{2}$ inches, but the majority of plants have staple about $1\frac{1}{2}$ inches in length. In Upland cottons the fibers on different parts of the seeds are sometimes of different lengths. It is usual to find long fibers at the end of the seed and short fibers at the base, giving the "butterfly" appearance when the lint is combed out on the seed. The Mit Afifi seed may also bear fibers of different lengths, but the long fibers seem usually to come from the middle of the lint-bearing area of the seed and the short fibers from the extremities. The Mit Afifi seeds are never as well covered with lint as seeds of the best Upland cottons, the lower half or third of the seed often having no lint. There is also much difference in the quantity of fiber borne by seeds of different plants. Some have heavily linted seeds, while others have seeds nearly bare. The fibers are also much stronger on some plants than on others.

The seed of the Mit Afifi cotton usually has a tuft of greenish or brownish fuzz at either end, and the tufts are often connected by a line of fuzz along the ridge of the angled side. All degrees are found on the one hand between such seeds and those that are perfectly smooth or nearly so, and on the other hand the fuzz may be more abundant and longer, until a close likeness to the fuzzy Upland seed appears. The rounded surface of the seed, opposite the flat side, is least likely to become fuzzy, especially the portion of it near the base of the seed. Differences also appear in the color of the fuzz, some seeds showing more green than others, but green fuzz is not so noticeable as in Jannovitch seeds, a large proportion of which have bright green fuzz. The range of diversity in seed characters of Mit Afifi cotton grown in Arizona for a single season can hardly be said

to be greater than in imported seed from which it is grown; the most that can be said is that the quantity of fuzz averages somewhat larger in the seed grown in Arizona.

Of the Mit Afifi seed imported in 1908 about 62 per cent had the usual fuzz tufted at both ends and sometimes extending along the raphe; in most cases the fuzz was green, though greenish brown and brown fuzz also occurred. About 6 per cent was naked or with only a minute trace of fuzz at the base. After the typical seeds and the naked seeds had been taken out the remainder were divided according to differences in the amount of fuzz into "nearly naked," "moderately fuzzy," "almost completely fuzzy," and "completely fuzzy." The first of these classes represented 21 per cent of the general total, and the other three classes, taken together, 11 per cent. Seeds that are completely fuzzy are represented by the smallest percentage—0.16 per cent. All these stages and degrees of fuzziness were found in seeds of otherwise typical shape, size, and color; that is, of a full oval or oval-pointed form, 9 mm. long, weighing $10\frac{1}{2}$ to $11\frac{1}{2}$ grams per 100, and of a uniform chestnut-brown color.

Though apparently independent of the amount of fuzz, many differences of shape, color, and markings could be found among the imported Egyptian seeds. About 25 per cent of all the imported seeds had longitudinal grooves for about one-fourth the distance or less from the base. These grooves were light colored, as if there had been checking of the surface as a result of shrinkage. Between the grooves the surface was black, darker than usual, and with a somewhat charred appearance. In a few cases the whole surface was checked or covered with a rough tissue like charcoal.

Some of the imported seeds were also aberrant in shape, size, or color. Some had very light or very dark seed coats, some were extra large, weighing 14 to 15 grams per 100, which is from 4 to 5 grams more than typical seeds, and others very small and weighing only $5\frac{1}{2}$ to $6\frac{1}{2}$ grams per 100. Long, flat, and round seeds were also selected. The long seeds were 1 mm. longer than the typical and with diameter much less in proportion to length than in typically shaped seeds. The flat seeds resembled apple seeds somewhat in shape and had the raphe along one edge. Blunt seeds, shorter than those of normal shape and for this reason more rounded, were described as "round." Altogether sixteen distinct seed types were selected for separate planting to determine whether any definite correlations exist between the characters of the seeds and the plants they produce.

While a considerable amount of this diversity among seeds has already been recognized in Egypt, it has not yet been found to be correlated with diversities in the plants, though it is evident from the reports of Mr. Balls that diversities are found in Egypt in the

flowers, bolls, and lint very similar to those that have appeared in Arizona.^a

ABERRANT TYPES IN IMPORTED JANNOVITCH AND MIT AFIKI COTTONS.

The most extreme forms of diversity in the plantings of imported seed were shown in a few plants that seemed to stand well outside of the general range of diversity of the varieties in which they appeared. Three cases of this kind were studied in the Jannovitch plot and three in the Mit Afifi. While there were notable differences between them, they had also a more general resemblance to each other than to the varieties in which they appeared. The flowers were in all cases of a very light creamy tint, the same as in our United States Upland varieties, and the petal spots were very faint or lacking altogether. The vegetative differences were much less conspicuous and might easily have been overlooked if the pale flowers had not drawn special attention to the plants.

The three Jannovitch plants represented two types. Two of these plants agreed in habits of growth and in flower characters. They displayed a more pronounced tendency toward branching at the base, and the long basal branches were unusually slender. The main axis was no stronger than the branches. The leaves of one plant were small and narrow lobed, while in the other they were large, slightly crumpled, and with broadly rounded lobes, the two extremes of Jannovitch leaves being represented by the two plants. The bolls, though of the usual dark, shining-green color, were unusually small and nearly round. In the number of their locks they did not differ from the other plants in the same block, one bearing 17 two-locked and 178 three-locked bolls, the other 4 two-locked, 170 three-locked, and 3 four-locked bolls. As in the case of the other Jannovitch plants grown from imported seed no fruit was borne below the middle of the plant. The bud and flower characters alone were the distinguishing features.

The bracts were small and quite distinct from Jannovitch cotton in shape and in the distribution of their teeth. They were frequently much broader than long, and with the margins evenly rounded; the teeth were small and uniformly distributed, without the separation of three at the tip of the bract common to Jannovitch cotton. The flowers behaved as though proterogynous, the stigmas protruding from the tip of the half-grown buds. This was due to the incongruous combination of the long Jannovitch pistil with very short petals, the petals being barely half as long as the average for the variety. In the open flowers the petals were about as long as the

^a Report of the Khedivial Agricultural Society for 1906, pp. 49 and 65.

bracts and the stigma often extended beyond both, a very infrequent condition in cotton flowers.

On one plant the flowers had no petal spots and on the other the spots were barely apparent in some of the flowers. Such correlation of light petals and faint petal spots have been known to occur only in cases of hybrids; the palest flowers of normal Jannovitch cotton have petal spots as dark as those with darker petals. Nevertheless, there was no indication that this plant was a hybrid with an American Upland cotton. The usual correlation of characters common to Egyptian-Upland hybrid flowers—bell-shaped white flowers with sharply lobed calyx and long stamens with light-colored pollen—did not occur in this white-flowered Egyptian plant. The pollen was as yellow as in typical Jannovitch cotton and the stamens were even shorter than usual for this variety.

The lint of one plant was nearly white, while that of the other was light buff. In both cases it was of good length and quality and of medium strength, the buff lint being stronger than the white. On the plant bearing white lint, only one or two seeds developed in a lock. Furthermore, these seeds sometimes failed to turn black.

The third of the diverse Jannovitch plants, representing the second type, was like the other two in approximating the Egyptian style of growth and foliage. The limbs were more spreading than usual and the leaves lighter green. In other respects it differed as widely from the other white-flowered Jannovitch as from the normal Jannovitch cotton. The bracts were of stiff Jannovitch texture, but were broad and cordate. The flower was about the size of the normal Jannovitch flower, but pale, with pale red spots. The calyx was sharply lobed, one or two of the lobes being greatly elongated. The internal nectary bore a distinct band of long, abundant hairs. The bolls were light green, larger than Jannovitch bolls, round, with a prolonged beak. Of the bolls 74 were four-locked, 23 three-locked, and 7 five-locked. The lint was tinged with buff and was abundant, short, and silky. The seeds were more nearly round than in normal Jannovitch cotton, and even larger than in American Upland varieties. Many of them were about two-thirds covered with a dense, green fuzz. Others were not so fuzzy, but all bore more fuzz than is usual for Jannovitch cotton. The naked surfaces of the seeds were black and irregularly pitted.

The three aberrant white-flowered plants in the block of newly introduced Mit Afifi cotton resembled the two already described as the first type in Jannovitch. In all but flower and boll characters these plants were indistinguishable from the normal Mit Afifi cotton. The flowers were white in all three cases and had no petal spots. The petals were much smaller than the average for Mit Afifi. The flowers

differed from those of the similar type in Jannovitch plants in not being proterogynous. Though the petals were short the pistil was likewise abbreviated; even in the open flower the pistil did not extend beyond the petals as in Jannovitch cotton. Differences only slightly marked in normal plants of the two varieties were accentuated in these white-flowered types. In all the white-flowered Mit Afifi plants the style protruded but slightly beyond the stamens, while in the Jannovitch plants the corresponding portion of the style was very long. The staminal tube of the white-flowered Mit Afifi plants was constantly longer than in the Jannovitch cotton. This accounted to some degree for the shorter extension of the style beyond the staminal tube in the Mit Afifi cotton, though the style is absolutely shorter in this variety than in Jannovitch. The point of origin of the staminal zone was higher above the base of the flower in Mit Afifi, and the zone itself was longer than in Jannovitch cotton.

The white-flowered Mit Afifi plants differed further from the two similarly aberrant Jannovitch plants in having a faint hairy rim above the internal nectary of the calyx. There was also a much larger percentage of four-locked bolls than in the aberrant Jannovitch plants, and two of the three plants bore a few five-locked bolls. The shapes of the bolls of the white-flowered Mit Afifi plants were diverse, varying from round to blunt-oval. There were also differences in size, the largest being $1\frac{1}{2}$ inches long by $1\frac{1}{2}$ inches in diameter. On one plant the bolls were light green and lacked the shining smoothness of surface usual in Mit Afifi cotton. Similar diversities in boll characters did not appear among the white-flowered Jannovitch plants.

One of the three Mit Afifi plants showed great degeneracy. Very little fruit had been retained, though the flowers were produced in normal abundance. The few bolls that reached maturity had sunken carpels and only one or two poorly linted seeds.

HYBRID NATURE OF THE ABERRANT JANNOVITCH AND MIT AFIFI PLANTS.

In some particulars the white-flowered Mit Afifi type is intermediate between the two Jannovitch types. In style of growth and in flower characters the white-flowered Mit Afifi plants are close counterparts of the first of the white-flowered Jannovitch types, except that they bear five-locked bolls like the second Jannovitch type. Their resemblance to the first type in Jannovitch is so marked that a similar foreign influence is naturally to be suspected.

But if hybridization is responsible for the diversity it also seems probable that the cross is of long standing. The preponderance of the Egyptian characters is large and the lint averages the same as that of normal plants except in a single individual. Two of the

white-flowered plants in the Jannovitch plots and the three in Mit Afifi differ less among themselves than do many of the normal plants of these varieties. Furthermore, indistinct varietal characters of normal plants are consistently accentuated and made prominent features of the aberrant plants, as often occurs in hybrids.

The combinations of characters found in the Jannovitch plant that gave the strongest indications of hybridity differ sufficiently from those observed in the known Egyptian-Upland crosses to make it reasonably certain that the source of contamination was not American Upland cotton, but seem to indicate that the foreign parent resembles Upland to some extent. The correlations of flower characters are the same as those that appear very frequently in the Egyptian-Upland hybrids. The petals are white, the petal spots faint, the calyx lobes pronounced, and there is a distinct hairy rim above the internal nectary.

The accentuation of the lobes of the calyx to such an extent as in one of the suspected Jannovitch hybrids finds no counterpart in the several generations of Egyptian-Upland hybrids which have been studied, and this plant also bears five-locked bolls with large, green-fuzzy seeds and short lint. The peculiar rounded shape of the seeds and their large size and partly naked, rough surface do not correspond with anything found among plants known to be Egyptian-Upland hybrids.

Considering the white-flowered Egyptian plants as hybrids, the most probable source of infection seems to be the "Hindi" cotton, an inferior, white-linted type not now planted in Egypt, but which persists as a weed and mixes with the Egyptian cotton to the great detriment of the fiber, as several investigators have reported. The Hindi cotton has white flowers without petal spots, and five-locked bolls, characters which in the plantings of newly imported Egyptian cottons at Yuma were peculiar to the aberrant plants alone. At the same time these plants do not have seeds like the Hindi cotton, which are said to be long, narrow, and free from fuzz, and thus easily recognized. A considerable effort has been made by the Khedivial Agricultural Society, of Cairo, to eliminate the Hindi plants by culling out the seeds from the commercial varieties, Mit Afifi in particular. Even in the best samples there is said to be an admixture of 2 or 3 per cent of Hindi seed.^a

This precaution has not been found adequate to eliminate all the plants with Hindi characteristics, which makes it evident that the

^a Foaden, George P., secretary-general of the Khedivial Agricultural Society. "The Selection of Cotton Seed," in Yearbook of Khedivial Agricultural Society for 1905.

Hindi peculiarities of the seed are not always obvious. This has also been appreciated in Egypt, as the following statement^a will show:

Finally, I may say that even in fields which have been picked free from Hindi, both on the seed tables and at thinning out, I have this year found a large percentage of plants bearing one or more inconspicuous Hindi peculiarities shuffled into the pack of Afifi characteristics.

It is evident from this statement that the only method of keeping the undesirable Hindi characteristics in abeyance is to maintain a still more efficient selection, based on more general knowledge of the characters that enable the Hindi hybrids to be detected.

MIT AFIFI COTTON MORE DIVERSE THAN JANNOVITCH.

While the plots of newly introduced Jannovitch and Mit Afifi cottons at Yuma fall far short of the standards of uniformity usually applied to Upland varieties, it seems that Jannovitch cotton approaches this standard more nearly than does the Mit Afifi. The flowers of Jannovitch plants are darker yellow and show less variation of color than do the flowers of Mit Afifi. The basal spots of the petals likewise are nearly always large and dark in Jannovitch plants, while in Mit Afifi there is more variation and all degrees from very dark to very pale spots. The portion of the pistil extending beyond the staminal tube is longer and more constant in length in the Jannovitch cotton. Only a few plants are found with the pistils abbreviated, a condition of rather frequent occurrence in Mit Afifi. The Jannovitch cotton also has a more regular form of boll, long and pointed, about 1½ inches in length by 1 inch in diameter. Blunt bolls are sometimes found, but the range of diversity is not so wide as in Mit Afifi. Here the usual shape is rather blunt, with an abrupt, short point, but some of the Mit Afifi bolls are even more pointed and narrower than those of the Jannovitch cotton.

DIVERSITY IN THE DALE EGYPTIAN COTTON.

A third type of Egyptian cotton planted at Yuma was the Dale, a variety of unknown ancestry only recently brought forward in Egypt and now planted for the first time in America.^b It differs from both the Jannovitch and the Mit Afifi varieties in peculiarities of its vegetative characters and habits of growth, quite as marked as the vege-

^a Balls, W. Lawrence. "Seed Selection," in Yearbook of the Khedivial Agricultural Society for 1906, p. 81.

^b Grown from seed sent to the Department of Agriculture by Mr. Alfred Dale, Mansurah, Egypt, with the following remark: "A special quality I have cultivated on my farm for the past year, which has given splendid results both in quality and quantity."

tative characters that distinguish Upland varieties. The range of diversity is also much greater than in the other Egyptian varieties, and in some respects is fully as great as would be expected in a series of hybrids.

Many of the plants have abnormally short fruiting branches like the "cluster" varieties of the Upland type. The bolls are often borne on very long peduncles and in clusters of three to six, or even more. The plants which bear their bolls in this manner are tall and spike-like, with coarse, dark foliage, characters also frequent in Upland cluster cottons. Other tall plants bear their bolls only at the ends of the branches, but not in clusters. Still other plants, including the tallest of all, are completely sterile. All the tall plants have long basal limbs, but the main axis is always strongly developed. A fourth style of plant is more nearly like the Upland, with normal fertile secondaries and bearing some of the fruit below the middle of the plant. This type of plant also resembles the Upland in bearing five-locked bolls. Indeed, it appears that five-locked bolls are of more frequent occurrence in the Dale type than are two-locked bolls, though plants bearing two-locked bolls also occur. The two-locked bolls were found on two small plants of a type rather aberrant in other respects. One of them had perfectly smooth seeds and very sparse, weak lint. The majority of the plants bear three-locked and four-locked bolls, the three-locked bolls being predominant. The locks were counted in the bolls of twelve plants and the percentage of four-locked bolls was about 15.

The range of diversity in the size and shape of bolls is much greater than in the other Egyptian varieties, and this is true also of flower characters. Large and small flowers, lemon and cream colored petals, and dark and pale petal spots are all represented in the planting. Even in the same flower the petal spots may range from dark to very faint on the various petals.

The bracts do not resemble those of the other Egyptian cottons, but are broad (some broader than long), more strongly lacinate, with the laciniae longer and broader than in Jannovitch or Mit Afifi cotton and without the Egyptian arrangement of three laciniae at the apex of the bract. There is also a notable frequency of abnormal bracts intermediate in form between ordinary leaves and fully specialized bracts. This series of abnormalities has a botanical interest in affording apparently conclusive evidence of the nature of the modifications that have been made in specializing leaves into bracts. The stipules become greatly enlarged, the blade correspondingly reduced, and the petiole eliminated entirely. The three large teeth in the middle of the bract represent the lobes of the leaf, the other teeth being borne

on the enlarged stipules. The nectary at the base of the bract corresponds to the nectary on the midrib of a normal leaf.

DIVERSITY IN LATER GENERATIONS OF MIT AFIFI COTTON.

Experiments with recently introduced Central American types of cotton have made us familiar with the fact that an even greater amount of diversity is often shown in the second and third generations than in the first, depending upon the extent to which the characters of the variety are disturbed by the transfer to new conditions.

That the total diversity should be greater in the second generation of a stock than in the first generation is easily to be understood from the fact that the seeds which produce the second generation must develop under the new conditions, whereas those which produce the first generation have been developed under conditions normal for the variety. A variation that takes place in a seed or a seedling is to be compared with the variation of a bud or branch rather than with the variations that occur when new conjugations take place.

That new conditions are even more likely to disturb the processes of heredity at the time of seed formation than during the previous period of vegetative growth is shown by the many instances of carefully selected varieties of vegetables and flowers which will produce one generation of normal plants under new conditions, but show marked diversity and deterioration in the second generation. Some of Mr. Kearney's special selections from individual plants have attained a uniformity notably greater than that of the new plantings of the Egyptian varieties, but in the bulk plantings, and especially in plantings made under conditions different from those in which the original breeding was done, a wide range of diversity is still to be found, in some respects even wider than in the plats raised from the newly imported seed. Nevertheless, it does not appear that this persistence of diversity is in the nature of a failure of acclimatization or that it indicates any special resistance to acclimatization on the part of this type of cotton.

The effect of the selection thus far applied can be fairly judged only by the selected stocks themselves, which are often very uniform. Apart from hybrids the diversity of the bulk plantings is largely explained by the diversity between the various selections whose seeds were combined in the bulk plantings. Considerable diversity could be ascribed very properly to the mixture of the seed of the different selections and the crossing of the selections among themselves. Indeed, it is a more difficult problem to explain the uniformity of the selections, unless we consider that some of them represent mutative variations which are sometimes notably prepotent and constant in

their progeny even when freely exposed to crossing with the parent form.

The fact that the Arizona-Egyptian plants were grown in large numbers and in several different localities under different conditions would also tend to increase the impression of diversity by giving more numerous opportunities for differences to appear. Finally, the presence of numerous and diverse Upland hybrids would itself tend strongly to establish an impression of diversity, even if the Egyptian plants themselves were more nearly alike than they are.

Differences in fertility, rather than in other special characteristics, is the most serious form of diversity and that which shows most definitely that acclimatization is still incomplete. Inequalities in the yield and the quality of the lint are frequently out of all proportion to any differences of natural conditions reflected in the stature or apparent vigor of the plants. This form of diversity was found to depend on the fact that the cotton plant bears two distinctly specialized kinds of branches, one fertile and the other sterile, as will be explained in later chapters.

DIVERSITY AFFECTED BY METHODS OF BREEDING.

The practical work of acclimatizing a foreign variety like the Egyptian cotton consists simply in the selection in each season of those plants that behave in a normal manner or in a manner which most nearly approaches the normal. The primary object of acclimatization is not to change or improve the variety, for which selection is often used in other cases, but to preserve the variety and rescue it from the agricultural deterioration which results from too great and indiscriminate diversity. Instead of attempting to bring about changes of characters our efforts are directed toward securing greater stability in the expression of the characters.

Even without any special selection there is often a distinct tendency to return toward the normal adjustments. Even when the first generation of a newly introduced cotton is nearly sterile each succeeding generation tends to be more fertile and productive. Nevertheless, it is hardly to be expected that there would be any complete return of the variety to its normal characters without the assistance of selection. The diversity which the new conditions arouse may be thought of as representing the same diversity that was suppressed when the variety was originated by selection. The new conditions having disturbed the adjustments and released the old diversity, a new selection is required to restore the previous uniformity, that is, to

separate again the lines of descent that have the strongest tendency to express the desired set of characters.

The process of acclimatization in the strict sense would be finished when the variety had been restored to a condition of stability, so that crops as normal and uniform as those of other varieties that are being planted in the same region could be raised. This has been accomplished in Texas with several strains selected from Central American stocks introduced four years ago.

The diversity aroused by the new conditions is likely to afford novelties which attract the interest of the breeder and furnish him very promising material for the development of valuable new types. Some of Mr. Kearney's best selections show vegetative characters quite different from the average form of the Egyptian plants and apparently quite superior. At the same time it has to be considered that the behavior of these new types may not be quite the same as if the normal, typical form of the parent variety had been retained. Among the Central American varieties at least, those strains seem to be most promptly acclimatized which are nearest to the ordinary form of the parent stock as it grew in Central America. Selections of such individuals often yield a very uniform progeny, whereas selections of other types continue to show a larger amount of diversity. Such instability may be compared to the instability of hybrids, in that the forms secured in this way represent new combinations of characters, or at least unaccustomed combinations. It is easy to understand that such new combinations may be less stable and less promptly reduced to uniformity than combinations that have been expressed with regularity for many generations.

Not only is there a distinction to be drawn between acclimatization and breeding, but a practical difference of methods may need to be used, at least in the case of cotton. If selections were kept inside of the varietal type and had only the minor fluctuating differences in degrees of fertility or lengths of lint, crossing between these selections might have no serious effect in retarding acclimatization. But where each selection is likely to represent a diversity equivalent to a distinct variety, the crossing of such selections may prolong the condition of instability, if it does not have a further tendency toward a deterioration or mongrelizing of the type. Free crossing among numerous varieties of the same species often leads the composite group back to the characters of the wild type and may produce a serious deterioration, particularly when the characters of the varieties represent the results of special selection.

The bearing of these facts upon the problem of acclimatizing the Egyptian cotton is not difficult to understand. To secure the most

rapid progress of the work of acclimatization it ought to be considered as entirely distinct from the work of securing improved types of Egyptian cotton. The selections for these two purposes should be conducted on separate lines and by different methods. The diverse forms, whether superior or not, should be removed from the stock that is being acclimatized. The normal form and habits of growth, combined with the normal fertility and the lint characters, should constitute the standards of selection, if prompt acclimatization and attainment of commercial uniformity are the principal objects. The development, testing, and substitution of new and improved types may be considered as representing a later stage in the development of an established industry. Even though distinct improvements can be made later on, it is likely to be an advantage to begin with the nearest possible approach to methods already tried and to products already in demand.

RELATION BETWEEN DIVERSITY AND EXTERNAL CONDITIONS.

It is a most familiar fact that plants of the same kind will show different characteristics when grown under different conditions. This power of the plants to adapt themselves to different conditions is very important in an agricultural species or variety if it is not to be restricted to one locality or set of conditions. Cotton is one of the most adaptable of plants, able to thrive and produce an abundance of seed under a very wide range of natural conditions, and able to make notable changes of form and habits of growth in accord with the needs of many different surroundings.

Nevertheless, this readiness of adaptability is not without its disadvantages, especially in such a plant as Egyptian cotton, where the uniformity of the product is quite as important as the amount of the yield. In changing the characters which have to be varied for the sake of adaptation to different external conditions, other characters are likely to be changed or to fall out of adjustment. Each fully developed plant represents a balanced combination of many characters.

Selection is our means of compelling a variety to repeat the particular combination of characters that we desire, but the adjustments established by the selective breeding of a variety under one set of conditions are often lost or diminished when the plants are transferred to a new set of conditions. Though new conditions may be equally favorable, or even more favorable, the close adjustment of the varietal characters are likely to be disturbed whenever there are

any changes or substitution among the characters which are affected by the external conditions. Even when a variety continues to be grown in the same place, seasonal differences of temperature and rainfall are often sufficient to disturb the adjustments of the characters, so that different years may bring great differences in the uniformity of the same crop.

The experiments with the Egyptian cotton at Yuma and at Sacaton may be viewed as an example of such a loss of adjustments. The natural conditions at Sacaton did not appear to be less favorable than at Yuma as far as they could be judged by the size and productiveness of the plants, nor did the total amount of diversity among the plants appear to be greater at Sacaton than at Yuma. Nevertheless, the effects of the selection for long lint which have been made at Yuma were notably less apparent at Sacaton. Very few plants, if any, showed as long lint as many of the better selections at Yuma. Most of the Yuma plantings had the advantage of an additional year of selection, which might have been expected to have a favorable effect upon the average of the lint, but can hardly be thought to explain the almost complete failure of even individual plants at Sacaton to attain the Yuma standards. Further experiments must determine, of course, the extent to which this difference represents a phenomenon of acclimatization. It is possible that the Sacaton conditions may be less favorable to long fiber than those at Yuma, but the general behavior of the plants does not lead us to expect any permanent difference of this kind.

This relative inferiority of the Egyptian lint at Sacaton made the hybrids appear more definitely superior to the pure Egyptians than at Yuma, though there was no indication that the Sacaton hybrids were really better than the Yuma hybrids. They seemed in fact to be not quite as good, and yet they gave a stronger impression of superiority over the pure Egyptians.

In this particular case the transfer of the plants to new conditions appeared to shorten the range of diversity rather than to increase it, there being less of the long lint shown at Yuma. But if acclimatization had been complete at Yuma, so that the long lint had become a more uniform character, the transfer to Sacaton would doubtless have caused the diversity to appear greater by allowing many of the plants to fall back to the short lint, after short lint had ceased to appear at Yuma.

IMPORTANCE OF HABITS OF BRANCHING.

The most marked effects of different conditions of growth are exerted through their influence upon the methods of branching. The

branches of the cotton plant are of two definitely different forms.^a Fertile branches are horizontal or drooping. Each joint bears a fruit bud, and the internodes are twisted to bring the buds to the upper side. Sterile branches, or "limbs," are upright or ascending, with long straight joints and no fruit buds. The sterile limbs are to be thought of as subdivisions of the main stalk and have the same function. Like the main stalk they can produce other branches which are fertile, but are themselves unable to set any flowers or fruits. If all of the lower branches are of the sterile, upright form the flower buds can not begin to form till the second generation of branches has been put forth. This delay contributes to the lateness of the crop, which is usually reckoned as a characteristic of the Egyptian type of cotton.

Nevertheless it appears that in Arizona, at least, heavy yields depend largely upon the size of the contribution made by the fertile branches formed on the main stem within 2 or 3 feet from the ground. The plants seldom attain any satisfactory degree of fertility unless they begin by putting forth many of the short horizontal fruiting branches from the lower part of the main stem. Reference to Plates I and II will enable the reader to gain an idea of the intimate relation between fertility and forms of branching.

^a In view of the practical importance of recognizing the two distinct kinds of branches, it may be well to add a summary of facts stated in a former publication. (*Weevil-Resisting Adaptations of the Cotton Plant*, Bulletin 88, Bureau of Plant Industry, pp. 19 and 20.)

Two buds are formed at the base of each leaf of a cotton plant. The bud that comes from the middle of the base or true axil of the leaf grows into a vegetative branch, never into a fruiting branch. These vegetative, axillary, or primary branches are like the main stem in that they produce fruiting branches, but they never produce directly any flower buds or bolls. The fruiting branches, as well as the flower buds they bear, arise in an extra-axillary position at the right or the left side of the true axillary bud. Thus each cotton stalk or vegetative branch is either right-handed or left-handed with respect to the arrangement of the fertile branches, conforming to the direction of the spiral in which the leaves are inserted.

External conditions may affect the development of the branches in two principal ways—by inducing the formation of an abnormal number of primary branches or by leading the secondary branches to behave like primary branches. Although axillary buds do not produce fruiting branches the extra-axillary branches often assume the form and behavior of vegetative branches. It is the regular habit of some types of cotton to keep the axillary buds in a dormant condition and to form vegetative branches by vegetative transformation of fruiting branches. After this change takes place there is no return to the fertile form. A branch that begins to grow without producing flower buds on the basal internodes never produces any flower buds. Unless branches of the fruiting type are formed no flower buds can be put forth and the plant remains completely sterile, no matter how large and luxuriant it may be. (*O. F. C.*)

If the plants have too strong a tendency to vegetative growth early in the season too many of the branches take on the sterile form. (Pl. I, fig. 2.) The plant may then fail to develop any of the lower fruiting branches or may leave them small and stunted. (Pl. I, fig. 1.) And even after a promising development of the fruiting branches has taken place and goodly numbers of bolls have been set, they may fail to attain a normal growth if the plant falls later on into the condition of too great vegetative luxuriance. Not only is there a cessation in the formation of more bolls, but even those that are already formed may shrivel and drop off, or may be able to form only abnormally short and weak lint. This direct evidence of the change of the plant's activity from the reproductive to the vegetative side is very common. Sometimes all the bolls of the lower part of the plant are inferior, and sometimes the lowest are notably better than those farther up, which could not have been so far advanced when the change of tendencies took place.

The unusual liability to change greatly intensifies the influence of the external conditions in determining the fate of the individual plants. A plant whose characters are more stable may resist all the influences that upset its less stable neighbors, which may yield to the disturbing influences at different stages of development, depending upon their different degrees of adjustment.

The fact that so many of the plants show normal tendencies of growth in the early part of the season indicates that high temperature is one of the decisive factors, but it is evident that conditions of soil and water supply are often very important in assisting or hindering the change. Rich soil and abundant water predispose the plants to greater luxuriance, while poorer and drier soils tend to hold them back, and thus favor greater uniformity. In the drier parts of the fields at Yuma all the plants (even including the hybrids) appear much more alike than where moisture is abundant. Thus it is probably an aid to acclimatization to keep the plants as far as possible under moderate conditions, to avoid an unnecessary intensification of the instability, and yet to allow the unstable plants to show themselves and be weeded out.

It might be argued that selection will be more efficient if the plants are placed under extreme conditions, so that their powers of maintaining the normal adjustments of their characters may be tested more thoroughly. The danger is that all of the plants may be changed beyond the range of normal behavior, and that this may increase the difficulty of bringing even the best selections back to a condition of practical uniformity. When the changes are too great and too general it also becomes more difficult to tell whether some plants are more normal than others. The plants that prove to be the most fertile in

the first seasons, when the work of acclimatization is carried on under extreme conditions, do not necessarily represent the best types for agricultural purposes.

The fact that the condition of the Egyptian cotton, with reference to fertility and acclimatization, can be determined from the way in which the branches develop in the early part of the season shows that this feature is of great practical importance. And after acclimatization has been accomplished the development of the fertile branches will be the chief issue with the farmer. Their behavior, more than anything else, will influence the choice of methods of culture as well as the times of planting and irrigation. It is already apparent that the application of too much water at the wrong time may not only diminish the crop but may actually injure the growing bolls.

Though writers on the behavior of Egyptian cotton in Egypt do not seem to have recognized the different types of branches and their relation to external conditions, they have not failed to report that too much vegetative vigor has an adverse effect upon the crop.

It is noticeable that, speaking generally, the best lint from the cotton grader's standpoint is not produced by the largest and strongest plants, so that in popular expression "running to wood" is objectionable. * * * The provinces of Menoufieh and Gharbieh produce the best cotton in the country, though the climate is less suited to mere growth of the trees than in those provinces which lie farther south. * * * A similar result, though the operating cause is apparently different, is obtained by the "Sea Island cotton" growers in America, who apply salt marsh mud to their crops. This apparently acts by checking root absorption and consequently growth.^a

Further indications of the methods used in Egypt to hold the vegetative growth in check and induce earlier fruiting have already appeared in a bulletin of this Bureau.

There has been during recent years a distinct tendency toward early planting, it being contended that during a series of years the largest yields, as well as the best qualities, are produced by early planters.

Early-planted cotton grows more regularly and evenly and does not tend to produce such coarse growth (weed) as that planted later. It also branches better from the bottom.

It is generally accepted that as long an interval as is consistent with the health of the plant should elapse before the first watering is given; otherwise the plant is not encouraged to root well, but tends to grow too rapidly. Too frequent waterings during the early growing period prevent the proper branching of the plants from the bottom. They grow too rapidly, producing their forms at the top rather than from the bottom, and are spindling.

The basis of the mixture of chemical manures employed is superphosphate. * * * It checks the tendency to coarse growth and thus encourages ripening, while it greatly improves the quality of the fiber.

^a Balls, W. Lawrence. Yearbook of the Khedivial Agricultural Society for 1906, pp. 38-39.

The use of fresh stable manure causes rank growth, late maturity, and an inferior fiber.^a

The same difficulties have been recognized among the planters of Sea Island cotton, and the measures of prevention used by them have been noticed in another publication of this Bureau.

This ridge system gives better results in two classes of cases, as follows:
 * * * (2) When, on account of the land being rich and well fertilized, Sea Island cotton grows too much to weed under level culture. In such cases the grower is compelled to adopt measures to turn the energies of the plant from vegetative growth to fruiting. This is done by restricting the root development. (1) by maintaining a compact subsoil, which the Sea Island planters accomplish in their deep, sandy soils by pasturing with cattle during the year of rest; (2) by regulating the moisture supply by the high beds; and (3) by root pruning by deep cultivation if the cotton needs it.

It is advised that planting be begun as early as the season permits. This varies in different years and sections from March 15 to April 10. Early-planted Sea Island cotton is found to make a more compact and fruitful plant, while late cotton tends to form a larger and coarser weed.^b

DIVERSITY AFFECTED BY DIFFERENCES OF LOCAL CONDITIONS.

From indications already given regarding the nature of the diversity of the newly introduced varieties it is easy to understand that they are especially susceptible to the influence of adverse conditions. Inequalities of soil or water supply which would affect thoroughly acclimatized varieties only to the extent of making the plants a little larger or smaller may disturb the adjustments of other characters in a partially acclimatized stock and bring about serious deterioration.

Many striking illustrations of this were found at Sacaton, where series of good and fertile plants would often be succeeded in the same row by considerable numbers of others which were notably inferior and unproductive. The definite groupings of the good and bad plants made it evident that something in the soil or water supply must have been the exciting cause of these differences. The inequality might have been extremely slight and temporary, but it was evidently sufficient to start the plants on different courses of development. That the change so generally affects the quality of the lint is not surprising if we consider the fact that the long lint of the Egyptian cotton is a highly specialized character likely to be affected by any disturbance of the process of development, whether by external conditions or by other forms of variation.

^a Foaden, George P. Notes on Egyptian Agriculture, Bulletin 62, Bureau of Plant Industry, U. S. Department of Agriculture, 1904, pp. 22-24, 28.

^b Orton, W. A. "Sea Island Cotton: Its Culture, Improvement, and Diseases," Farmers' Bulletin 302, U. S. Department of Agriculture, pp. 24 and 25.

That otherwise imperceptible differences of conditions in the same fields have been able to exert such notable effects upon the cotton plants affords additional testimony to the fact of instability. It appears more reasonable to believe that the general shortening of the lint at Sacaton may be largely due to the change from Yuma to Sacaton rather than to any directly unfavorable factor in the natural conditions at Sacaton that will prevent the production of longer lint in future years.

A similar deterioration has been observed in Texas, even in the standard varieties of Upland cotton, when carried to different localities. Thus the Triumph cotton bred by Alexander Mebane at Lockhart, Tex., showed notably greater diversity and a lower average in lint when first taken to a higher elevation at Kerrville, Tex. That this deterioration represented the result of the change of conditions rather than of essentially unfavorable conditions was shown by experiments made at the same time and place with plants of the same stock, but raised from seed of normal plants grown at Kerrville in the previous year. The second generation plants were notably superior to those raised from the new Lockhart seed. In a series of such experiments the differences in yields ran between 10 and 20 per cent in favor of the second plantings of the same stocks over first plantings. The improvement in the quality of the lint was even greater.

DIVERSITY IN EGYPTIAN-UPLAND HYBRIDS.

To judge of the degree of acclimatization that has been attained as evidenced by the present extent of diversity in the Egyptian cotton is rendered much more difficult by the presence in the fields of many hybrids between the Egyptian cottons and various Upland varieties. These hybrids not only afford endless gradations and combinations of the parental characters, but the characters are often exaggerated in the hybrids and carried beyond the extremes of the parental types. Primitive characters not commonly represented in the parent stocks may also be brought back to expression in the hybrids.

Instead of being intermediate in size between the large Egyptian and smaller Upland plants the hybrid plants are usually much larger than the Egyptian. The seeds of the hybrid may be larger than those of either parent and they may be more fuzzy than the Upland parent or more completely naked than those of the Egyptian. The most important feature of all, the lint, does not obey the customary rule of intermediate expression of parental characters. Instead of the long Egyptian lint being shortened by combining with the short-linted Uplands there is usually a definite increase in length and strength, especially in the first and second generations. This supe-

riority of the fiber of the hybrids was readily appreciable in the general field plantings, especially at Sacaton, but was less pronounced in the specially selected stocks at Yuma.

The notable superiority of the lint of hybrids over that of pure Egyptian plants is one of the most interesting facts established by the present study of diversity. Together with the problem of learning how to prevent and eradicate the hybrids, we have also to consider the still more interesting and important possibility of learning whether superior hybrids can not be grown in regular commercial quantities and utilized as a practical means of producing cotton of very high quality.

FREQUENCY OF CROSS-FERTILIZATION.

The experiments with Egyptian cotton in Arizona confirm the results of our Texas experiments in showing that cross-fertilization takes place in a much larger proportion of cases than previous writers on the subject have supposed. The large, showy, open flowers of the cotton plant invite the visits of insects, so that a large amount of cross-fertilization has to be expected whenever different varieties or types of cotton are grown in the same vicinity close enough together for the same bees to visit the flowers of more than one kind.

As the amount of cross-fertilization depends entirely on the number and activity of the bees or other insects that visit the flowers different localities might be expected to differ greatly in the amount of cross-fertilization, and even the same locality in different parts of the season. Thus at the time of our visits to the fields at Yuma and Sacaton there was a notable difference in the activity of the insects at the two places. Several species of large wild bees that were industriously visiting the flowers at Yuma in September were not seen at all at Sacaton.

The fact that cotton flowers readily set seed from their own pollen has led several writers to suppose that cross-fertilization takes place only rarely, but the fact seems to be that foreign pollen is very often brought to the stigmas by the bees before the pollen of the same flower can reach them. This is particularly true of the Egyptian cotton, where the long styles carry the stigmas well up beyond the reach of the short stamens. In Upland varieties which have the stigmas shorter and the stamens longer the opening of the anthers brings the pollen against the stigmas without external assistance, but a long-styled Egyptian flower might remain unfertilized unless visited by insects. The pollen grains of the cotton plant are too large to float about in the wind and also have their surfaces moist and sticky. At

the same time they are covered with spines which keep them from adhering too closely to each other and yet help to hold them on the hairs of the bees, as well as on those that cover the stigmas.

The idea that cross-pollination is not frequent has probably been strengthened by the fact that hybrids are easily overlooked in experiments where only Upland varieties are being planted. This is because many of the hybrids have a rather close resemblance to one or the other of the parents or are merely intermediate between them. No such range of diversity appears as when two widely different types of cotton are crossed. Hybrids between the two related Upland varieties are generally much less different from the parents than the diversities that arise in the parent varieties without hybridization. And since the usual effect of hybridizing similar varieties of Upland cotton is to shorten the lint, many such hybrids may be thrown out in the process of selection without their true nature being recognized.

When Upland cotton is hybridized by an Egyptian or Sea Island variety the lint does not deteriorate in the first generation, as compared with the long-stapled parent and the hybrid character of the plant usually becomes obvious at once by reason of its greatly increased stature, which equals or exceeds that of the Egyptian parent. The large size naturally draws attention to the many other features of the Egyptian cotton which are predominant in hybrids with Uplands. This predominance of the Egyptian characters, which makes it so easy to detect Egyptian hybrids in Upland varieties, has the opposite effect of increasing the difficulty of recognizing all the plants of Upland parentage in a field of Egyptian cotton. In the first generation it is still very easy to distinguish them in the great majority of cases. In spite of the general resemblance to the Egyptian parent in stature and habit of growth there are many unmistakable features which enable nearly all of the hybrids to be detected without difficulty; but there are others which only those who have made a special study of the subject can hope to recognize, and some in which the most careful inspection has failed to detect any certain indication of a mixed parentage even when known to exist. If only the first generation of the hybrids had to be feared it is possible that the purity of a variety might be safely guarded, but when hybrids have been diluted for several generations of crossing back upon one of the parental stocks it becomes well-nigh impossible to separate them.

Even the most skillful selection can not eliminate hybrids from a cotton variety unless they are taken out before they begin to blossom. Rejection of the seed of the hybrid plants does not dispose of the other seeds borne by other plants which have been fertilized by the

hybrid pollen. And even though the plants raised from these seeds should again be rejected, the process of forming hybrids may still continue. The foreign blood would become more attenuate, of course, with each generation and the hybrids would more and more resemble the pure stock.

Many plants in the Egyptian experiments show such slight and indefinite departures from the Egyptian type that it is often very difficult to settle upon the non-Egyptian characteristics of particular individuals. But when the abundance of these doubtful cases is taken into account it becomes in itself a sufficient evidence of the fact of hybridity, when a planting is considered as a whole. The objection to these dilute or doubtful hybrids is not alone that they are likely to produce a slightly different lint, which lessens the uniformity of the commercial product, but that they are likely in later generations to give rise to distinctly degenerate plants, which will show some obvious hybrid character and a marked deterioration of lint.

DISTINCTIVE CHARACTERS OF HYBRIDS.

The facts already stated regarding hybrids show that it will always be necessary to guard against hybridization and to recognize it at once if it occurs accidentally, in order to prevent its extension in districts where Egyptian cotton is being grown. The farmer who grows Egyptian cotton, as well as the specialist who studies the crop, will need to be informed regarding hybrids. Thus it seems worth while to place on record some of the more salient facts established by our studies of diversity among the hybrids of the Upland and Egyptian types of cotton, in order to show something of the relative importance of the different characters as evidences of hybridization.

STATURE AND METHODS OF BRANCHING OF HYBRIDS.

Many hybrid plants are conspicuous by reason of their more robust stature. Having greater vegetative vigor than the plants of unmixed descent they grow to larger size. Many robust plants are tall, so that they stand out, even at a distance, but in others the large size is attained by putting out more numerous spreading limbs.

The range in the size of hybrid plants is very wide. Small Upland-like plants 2 to 3 feet high are found (Pl. III, fig. 1) beside huge overgrown plants from 5 to 10 feet high (Pl. III, fig. 2).

A similar wide diversity occurs in the shape of the hybrids. Upright, symmetrical plants of the Upland type are found, but the tall, overgrown plants are constructed on an entirely different plan, usually having basal limbs as long as the main axis.

PRIMARY BRANCHES OF HYBRIDS.

Hybrids often diverge from the pure Egyptian habits of growth in showing a more definite tendency to develop primary (axillary) vegetative limbs instead of forming vegetative limbs by modification of the secondary (extra-axillary) branches that would otherwise bear the fruit. The growth of two branches from the same node is more frequent in the hybrids than in pure Egyptian plants.

Many Upland plants put forth the primary limbs after the fruiting secondaries have developed. The usual habit of the Egyptian cotton seems to be to transform the lower secondaries into vegetative limbs, leaving the primaries entirely undeveloped, unless there has been a severe check or injury or the plant assumes more vigorous habits of growth after fruiting branches have already put out from the lower joints of the stem.

STRONG FERTILE BRANCHES OF HYBRIDS.

Upland cotton has relatively stronger and more horizontal fertile branches than the Egyptian. Hybrids often show this feature in a notable degree and then appear very different from the Egyptian plants. (Pl. III.) The latter usually have short and rather weak branches, which become drooping or pendent if they attain any considerable length. The branches of the Upland cottons and the strong-branched hybrids are borne down, of course, when the bolls become heavy, but this does not keep their relatively greater development from being apparent.

The greater tendency of the Upland cotton to put forth fruiting branches from near the base of the main stalk is often shown in the hybrids, even when the Egyptian tendency to develop limbs becomes predominant in the later growth of the plant and causes the lower fruiting branches to appear small and stunted. The unmixed Egyptian plants may also put forth small fertile branches at the base of the main stalk, especially if the plants do not grow too luxuriantly in the early part of the season. These low-fruited branches often remain small and stunted if the plants change their habit of growth a little later, but some of the hybrids make this change less readily than the Egyptian cottons and thus show a larger development of the fruiting branches near the base of the central axis of the plant.

FOLIAGE OF HYBRID PLANTS.

The hybrid nature of many plants is made apparent by their leaves. Frequently the leaves have a distinct reddish tint, a character of

Upland cottons. This color is often notably lighter than in the unmixed Egyptians. The light-colored plants usually have the leaves of rather thin texture and with broader, shorter lobes, usually borne in a more definitely horizontal position. This is likely to be true also of other hybrids whose leaves offer no other obvious marks of distinction except that they may have longer and more numerous hairs, especially on the lower surface. Hybrids can not be definitely distinguished from pure Egyptian plants by the texture of their leaves. The leaves may be thin and flexible, as in American Uplands, or even more thick and rigid than in pure Egyptian. Often they are of the texture of Egyptians.

The shape of hybrid leaves varies considerably, not only on the different plants but on the same plant, a condition of diversity more or less common to all cottons. The leaves on the main stalk and limbs are larger than those on the fruiting branches. Some leaves are more deeply cleft than others and the margins of some are crenate, which gives them a wavy outline. In some leaves the lobes are rounded, while in others they are acute.^a

Three-lobed, five-lobed, and seven-lobed leaves occur, those on the main stem usually having the greatest number of lobes. The bases of the three-lobed leaves are generally oblique to the petiole and straight, while those of the five and seven lobed leaves are either rounded, cordate, or overlapping.

Few of the hybrids have either very hairy or entirely glabrous leaves. Many plants have the leaves hairy on the lower surface, but few bear leaves with hairs on their upper surface; occasionally a plant occurs with entirely smooth leaves. On sparsely hairy leaves the hairs are generally stellate, but on those more densely covered the hairs are simple. Marked hairiness on leaves or other parts of the plants is a clear indication of hybridity. It is considered in Egypt that a reddening of the base of the leaf is an indication of hybridization with the Hindi cotton.

^aMr. H. M. Leake, of India, has investigated the leaf forms of hybrids between varieties of Indian cotton by means of what he calls the "leaf-factor," the ratio of length to width in the middle lobe. As a result of over 10,000 measurements he decides that the average ratios for the hybrids are intermediate between those of the parent types in the first generation. The application of this method to the second and later generations would be still more laborious, owing to the greater range of variation in these generations, and could have no practical value in the detection of hybrids, at least in the series studied by us, because many of them repeat the parental peculiarities or even exceed them. See Leake, H. M., *Journal and Proceedings of the Asiatic Society of Bengal*, January, 1908, p. 14.

VARIED PHYLLOTAXY OF HYBRIDS.

The normal arrangement of the leaves and branches of both Egyptian and Upland cottons is a three-eighths spiral. Each leaf is separated from the leaf directly above it by eight joints of the stem. A spiral connecting the two leaves and passing through the bases of the intervening leaves makes three turns around the stem. Hybrids may show any one of four different spiral arrangements. Plants with a one-third, two-fifths, or five-thirteenths spirals should be taken as hybrids, though many hybrid plants may have the three-eighths arrangement as in the parent types.

This arrangement is characteristic of the main stem and of the vegetative branches. The leaves on the fruiting branches appear to alternate in a one-half arrangement on all plants, due to the twisting of the internodes to bring all the flowers on the upper side of the branch.

SIZE AND TEXTURE OF BRACTS IN HYBRIDS.

There is a great range in the size of the involucre bracts of hybrid plants. They vary from small bracts, which are often red and which approach most closely the Upland type in texture, to the large, green, bullate bracts with the stiff, brittle texture of the Egyptian plants. The enlarged bracts greatly exceed in size the bracts of either parent, corresponding with the overgrown condition of the hybrid on which they occur. Only the small hybrid plants which adhere closely to the Upland type in other characters bear bracts of pure Upland texture. The mature bracts of most hybrids are rather stiff and brittle, though frequently more pliable in the younger stages of growth than young Egyptian bracts. Because of their Egyptian-like texture the mature bracts on drying have a tendency to curl in like Egyptian bracts, and in this condition are hardly distinguishable from the Egyptian type.

CORDATE FORM OF BRACTS OF HYBRIDS.

Some of the most reliable characters for the ready distinction of the hybrids are to be found in the larger size and the broader and more cordate form of the bracts of the involucre. The bases of the bracts are extended downward each side of the flower stalk into broadly rounded lobes, so that the flower stalk appears to be inserted in a deep notch. In the Egyptian cotton the bracts have no such conspicuous broadening at the base and seldom extend much below the line of attachment to the flower stalk. (Pl. V.)

LONG TEETH OF BRACTS OF HYBRIDS.

The marginal teeth of the bracts of hybrids are longer, broader, and more numerous than in unmixed Egyptian and are often hairy, at least along the margins. Conversely, the notches between the teeth are narrow and sharp in the hybrids instead of being broad and rounded as in the Egyptian cotton. Hybrids with well-developed bracts usually have from 12 to 14 teeth, while the normal number of teeth on the bracts of Egyptian ranges from 6 to 10. They are usually uniformly distributed, each tooth standing by itself, though infrequently three of them may be grouped at the apex, as in the Egyptian parent. The veins of the bracts are also more numerous in hybrids, to correspond with the larger number of teeth, and are generally more prominent, especially on the outer surface, while in the pure Egyptian plants the veins are more prominent on the inner surface of the bracts. (Compare bracts shown in Pls. IV and V.)

Though the numbers and forms of the teeth usually afford the best means of distinguishing hybrids they may give little assistance in difficult cases that approach closely to the Egyptian type. Sometimes the Egyptian forms and numbers of the teeth are preserved, the only sign of hybridity being the greater length of the teeth. In rare cases hybrids may even reduce the number of teeth below that of the Egyptian parent instead of increasing it. Thus at Yuma a hybrid plant was found in which some of the bracts had only 3 or 4 teeth, though others had 6 or 8, like the Egyptian parent. And yet in several other respects this plant showed distinctly Upland features. Even the bracts themselves, with the reduced numbers of teeth, were hairy on the outside, as in the Upland cotton.

REDDENING OF BRACTS OF HYBRIDS.

The outer surfaces of the bracts of many hybrids have a dull pinkish or reddish color, especially those exposed to the sun. This reddening often appears when the bracts are quite young. Sometimes it deepens with age, but on other plants only the young bracts show the reddish tinge. The tendency comes from the Upland cottons, where it is often very pronounced, while among the Egyptian cottons there is seldom any definite trace of it, though an occasional bract may appear somewhat reddish. Thus it may be said that any obvious reddening of the bracts gives reason for suspecting hybridity, and that any decided tendency to the red color is a fairly sure indication and likely to be accompanied by other obvious Upland features.

ABNORMAL FORMS OF BRACTS IN HYBRIDS.

Abnormalities in the form of the bracts are not infrequent in hybrids and are to be considered as one of the evidences of hybridity.

especially when many abnormal bracts occur on the same plant. These abnormalities take many forms, but they all appear to represent intermediate stages between normal leaves and normal bracts. It often happens that the leaf at the base of the flower stalk takes on more or less the character of a bract. The slightest and most frequent indication of the change is seen when one of the stipules is enlarged. Sometimes both stipules are enlarged, and one or both of them may be joined to the reduced and shortened blade of the leaf, the petiole being more or less completely suppressed. Finally, bracts which are quite normal in other respects may have one or both of the lateral divisions, which represent the stipules, separated to the base, or the bracts may be in irregular positions or may be abnormal in number.

Involucres composed of only two bracts occur on some of the hybrids, but are not as frequent as in the pure Egyptian stocks raised from newly imported seed. Two-bracted involucres may or may not be accompanied by two-locked bolls. The four-bracted involucres which occur occasionally in Upland cottons have not been observed in the hybrids.

Next to the lint itself, the involucre probably represents the most highly specialized structure of the cotton plant. It is therefore not surprising that hybrids should show these irregularities in the forms of the bracts. Indeed, it seems rather remarkable that such irregularities do not appear in a larger proportion of the hybrids, in comparison with the parent stock. The plants grown from the seed obtained from Mr. Dale showed more frequent and striking examples of abnormality in the bracts than any of the hybrid stocks.

DISTINCT CALYX LOBES OF HYBRIDS.

In many hybrids the calyx, instead of having the nearly straight, even rim of the Egyptian parent, is definitely lobed, as in the Upland cotton. (Pl. V.) Sometimes the lobes are even sharper than in some of our Upland varieties. As in the Upland cotton the largest lobes are those that bear nectaries, those that stand opposite the openings between the bracts. A lobed calyx affords only corroborative evidence of hybridization, since it seems always to occur in connection with other more apparent hybrid characters, such as the broad, long-laciniate bracts. With white, bell-shaped flowers of the Upland type the calyx is constantly lobed, and these also have a prominent hairy rim above the internal nectary of the calyx, as in Upland cottons. The absence of lobes can not be accepted as evidence of pure blood, for plants with other distinctive features of hybrids may have no lobes on the calyx or only the very broadly rounded, scarcely appreciable scallops frequent among pure Egyptian cottons.

A stronger development of the ring of hairs above the internal nectary of the calyx is also to be considered as an indication of Upland ancestry. This character seems to be especially prepotent in hybrids with Kekchi cotton.

LIGHT-COLORED FLOWERS OF HYBRIDS.

Many of the hybrid flowers share the pale, creamy white color of the Upland parent. This renders pale-flowered hybrids very conspicuous among yellow-flowered Egyptian plants and affords a ready means of separation. But, unfortunately, not all of the hybrids have the creamy flowers. In some of the hybrid plants the flowers are of a pale yellow, while others have them as dark as any of the Egyptian cottons.

PALE SPOTS ON THE PETALS OF HYBRIDS.

Many of the hybrids lack the dark reddish purple spot found at the base of each of the petals of Egyptian cottons, others have faint or broken spots, while still others have the spots as dark as in any of the Egyptians. The variations of the spot seem to be quite independent of those of the color of the petals. Though spots are most frequently absent in the light, creamy flowers, the pale flowers may also have very dark spots, or the deep yellow flowers may have faint spots, or none at all. If, in addition to this variability among hybrids, we consider the fact that pale petals and faint spots sometimes appear among the newly imported Egyptians, it becomes apparent that these color characters alone are not to be relied upon for distinguishing hybrids, except as they add to the evidence afforded by other features.

LARGE PETALS OF HYBRIDS.

Measurements show that the petals of hybrids are not only much larger than those of Upland cottons, but are generally larger than those of pure Egyptian plants. At Sacaton the petals of hybrids ranged from $2\frac{1}{4}$ to $3\frac{1}{2}$ inches long by $1\frac{3}{4}$ to $2\frac{3}{8}$ inches broad, while those of the pure Egyptian petals averaged distinctly smaller, ranging from 2 to $2\frac{1}{8}$ inches long by $1\frac{1}{2}$ to 2 inches broad. At Yuma the petals averaged smaller both in the hybrids and in the pure Egyptian flowers and the differences between the two were less. Though the hybrid flowers are usually larger than the Egyptian, large flowers are not a positive indication that the plant is a hybrid. Some hybrids have flowers which are smaller than many of the Egyptian flowers.

CUP-SHAPED FLOWERS OF HYBRIDS.

Hybrids with pale petals also share the Upland shape of the flower. The petals spread more widely apart near the base and give the

flower a more open, cuplike shape, obviously different from the more cylindrical or tubular form of the Egyptian flowers, which never open so widely as those of the Upland cotton. This wider opening of the pale flowers increases the resemblance to the Upland parent, while hybrids with flowers of a deep yellow color usually have the complete Egyptian form as well. (Pl. VI.)

DARKENING OF OLD FLOWERS OF HYBRIDS.

The flowers of the Upland hybrids, though usually paler when fresh than the Egyptian flowers, turn darker with age, first becoming pink and then deepening into dull purple as the corolla shrivels and dries, whereas the old flowers of the Egyptian cotton usually remain yellow or darken only a little. This difference was very noticeable at Yuma, where Mr. Kearney had made use of it for distinguishing the hybrids, but at Sacaton it was found to be much less reliable, for many apparently pure Egyptian plants were found in which the old flowers had turned to a dull purple or were blotched and spotted with purple to nearly the same extent as in Upland varieties and hybrids at Yuma.

LONGER STAMENS OF HYBRIDS.

Many hybrids, and especially those with pale flowers, have the filaments or stalks of the stamens like those of the Upland cotton, much longer than in the pure Egyptian. (Pl. V.) These longer filaments require more room than the narrow tube of the Egyptian flower affords. This fact may help to explain the apparent correlation between the light color and more open Upland shape of the flowers. As the light flowers almost always have long stamens the more open shape may follow as a mere mechanical necessity.

Hybrids that have long stamens like the Upland parent do not show very plainly the regular Egyptian arrangement of the stamens in five double longitudinal rows. Other hybrids have the numbers of the stamens greatly reduced, and in these the rows may be very apparent. More or less complete abortions of the stamens are rather frequent in hybrids. The anthers may fail to develop to the full size or may appear to be fully formed and yet fail to open. With the long filaments of the Upland parent anthers of the smaller Upland type are usually associated.

PALE POLLEN OF HYBRIDS.

Pollen grains of very irregular sizes are often found in the anthers of hybrids, and sometimes there appears to be a distinct diversity of color, though this is not easy to determine, because the apparent color of the grains differs so much in different lights, even when the color

is really uniform. Pale-flowered plants usually have the pollen also of a pale creamy or yellowish shade, while the pollen of yellow-flowered plants often shows the deep orange of the Egyptian parent.

THICKENED STYLES OF HYBRID FLOWERS.

The style is uniformly thicker in white-flowered hybrids; nearly as thick as in the Upland type. In some hybrids the styles are as short as in the Upland cottons, while in others they are intermediate in length between the Upland and the Egyptian. They are seldom as long as in pure Egyptian. (Pl. VI.)

PEA-GREEN BOLLS OF HYBRIDS.

Many hybrids can be distinguished at once by the light pea-green color which renders the bolls obviously different from the dark-green bolls of the Egyptian. The lighter shade of green is largely due to the fact that the oil glands are fewer in number or more deeply sunken and covered with green tissue, as in Upland cotton, instead of being exposed on the surface as in the Egyptian. (Pl. V.)

Bolls that have the light color almost always show something of the large size and more broadly pyramidal shape of the bolls of Upland cotton and thus appear the more distinct from the narrower and more cylindrical bolls of the Egyptian. Nevertheless, there appears to be a complete series of gradations in sizes, colors, and shapes. Plants shown by other characters to be hybrids may bear bolls which by themselves would appear genuinely and typically Egyptian. As already noted in the discussion of the Egyptian varieties, they show a much greater amount of diversity in boll characters than would be expected in any well-bred Upland variety. This adds, of course, to the difficulty of using boll characters as a means of distinguishing hybrids, except in the cases where the lighter color and different texture of the surface are obvious.

FIVE-LOCKED BOLLS OF HYBRIDS.

The bolls of hybrid plants are able to show the complete range of diversity of the parent types. Many hybrids have 2 to 4 locks, like the Egyptian parent, while others have 3 to 5 locks, like the Upland parent. Five-locked bolls are so rare a phenomenon in Egyptian cotton that they are always to be considered as an indication of hybridity. Nevertheless, it has not been necessary to reckon any plant as a hybrid because of this character alone, for it seems never to appear in a hybrid except in connection with other obvious Upland features. Five-locked bolls seldom appear singly; where one is found, several others are to be expected if the plant is at all productive.

Sometimes the number of five-locked bolls nearly equals that of the four-locked, but such cases are not common. Plants with numerous five-locked bolls are likely to have very few with three locks or none at all. When there are no five-locked bolls an absence of three-locked bolls or any notable preponderance of the four-locked bolls over the three-locked may serve to call attention to a hybrid. There is said to be a popular impression in Egypt that even four-locked bolls are found only on hybrids. This may be true in districts where the plants attain only small size.

The representation of five-locked bolls among the Egyptian hybrids in Arizona appeared to be distinctly less than in the hybrids between Kekchi cotton and Egyptian, which had been studied previously in Texas. Some of the long-staple Upland varieties have very few five-locked bolls, but there had also been opportunities of crossing with big-bolled varieties, where five-locked bolls are usually more numerous than in the Kekchi. It is possible that the five-locked tendency is more effectively inherited from the Kekchi cotton or that the difference represents an influence of the external conditions, which have been found to have definite effects upon the number of locks.

TWO-LOCKED BOLLS OF HYBRIDS.

Hybrids often exceed the pure Egyptian plants in the proportion of two-locked bolls. At Sacaton the bolls of pure Egyptian plants were quite consistently three-locked, the proportion of two-locked bolls being notably less than on many plants which were obviously hybrids. It seemed at Sacaton that any large number of two-locked bolls was as good an indication of the hybrid nature of a plant as a similar abundance of four-locked bolls. An average of 4.6 per cent of two-locked bolls was found on seven pure Egyptian plants. The highest percentage for any one plant was 12, and this plant also had the greatest number of two-locked bolls. Some of the hybrids are as consistently three-locked as any of the pure Egyptian plants.

At Yuma Messrs. Kearney and Peterson had formed an impression that the number of two-locked bolls was greater in 1908 than in previous seasons, which would accord with other indications of less favorable conditions for the cotton. Seven of ten plants of acclimatized Mit Afifi at Yuma were found to have two-locked bolls in the average proportion of about 5 per cent, nearly the same as at Sacaton. Of ten plants taken at random in a plot grown from imported Mit Afifi seed nine had two-locked bolls—in the general proportion of 13.4 per cent. Similarly striking reductions in the numbers of locks of the bolls have been found to take place in Central American varieties when first introduced into Texas.

FUZZY SEEDS OF HYBRIDS.

A majority of hybrid plants have their seeds covered with long dense fuzz. The color of the fuzz varies from green through the different shades of brown to white. A large proportion of the hybrids can be distinguished by the long dense fuzz, but this is by no means a safe guide in all cases. Very fuzzy seeds were found, as already described, in the newly imported Egyptian cotton, and on the other hand many hybrids have seeds more completely naked than the seeds of the pure Egyptian. Indeed, Mr. Kearney has noted among some of his special selections that the smooth seeds of hybrids fall into a rather distinct class. There appear to be very few hybrids with the same amount of fuzz that is usual in the Egyptian cotton. Those that have less fuzz than the Egyptian usually have much less or none at all.

A plot grown by Mr. E. W. Hudson at Sacaton, Ariz., from carefully selected smooth seeds contained nearly as large a proportion of obviously hybrid plants as a row that had been planted from a selection of the fuzziest seeds. Many plants grown from the fuzzy seeds showed no definite indications of hybridity, and the seeds of these plants in many cases bore as little fuzz or less than those of pure Egyptian plants. Plants were also found in other fields that had densely fuzzy seeds, but no other hybrid characters. The full range of diversity in seeds of hybrids is from perfectly smooth to densely fuzzy, fully covering the range of diversity for both the parent types and extending beyond.

Plants that appear distinctly degenerate in the strength of the fiber or in the number of seeds in the lock often have seeds that are completely devoid of fuzz. On the other hand, many of the very smooth-seeded hybrids at Yuma had fiber that was excellent in strength and in all other characters, comparing very favorably on the average with the lint from the fuzzy-seeded hybrids.

SIZE OF HYBRID SEEDS.

The seeds of hybrids range in size from that of Egyptian to an accentuated size larger than that found in Upland cottons. Hybrid seeds which come within the range of diversity for fuzziness in the seeds of newly imported stock may exceed the imported seeds in weight by 1 or 2 grams to the hundred. The majority of fuzzy seeds are of the size of Upland seeds, but some are of enormous size, nearly twice as large as those of Upland. In Kekchi $\times$ Egyptian hybrids the seeds are very large and have green fuzz in the first generation, these features tending to disappear in the second and third generations.^a

^a Cook, O. F. "Reappearance of a Primitive Character in Cotton Hybrids," Circular 18. Bureau of Plant Industry, U. S. Department of Agriculture. 1908.

It seems to be a general rule that fuzzy seeds attain a larger size than those that have less fuzz. The largest of the fuzzy seeds were selected from six different lots and found to average larger than the largest of the seeds that remained.

Weights of fuzzy and normal seeds.

[Stated in grams per 100 seeds.]

Weight of selected fuzzy seeds.	Weight of largest of remaining seeds not unusually fuzzy.	Weight of selected fuzzy seeds.	Weight of largest of remaining seeds not unusually fuzzy.
<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
17.06	14.46	17.55	14.11
16.91	14.78	17.67	13.98
17.96	14.48	15.93	15.30

In five of the six cases there was a notable difference in favor of the fuzzy seeds. It is perhaps worthy of note that the figures showing the smallest inequality were derived from a plot which consisted largely of hybrids. Here the fuzzy seeds were smaller and the non-fuzzy larger than elsewhere.

SUPERIOR LINT OF HYBRIDS.

One of the notable peculiarities of the hybrids lies in the fact that the lint of the first generation hybrids is often superior to that of the pure Egyptian plants. The proportion of first generation hybrid plants having very long, fine, strong lint is also notably higher than among the pure Egyptian plants. At the same time hybrids are frequently to be found which are as bad or worse than the poorest of the Egyptians, with very short, very sparse, or very weak "perished" lint.

The superiority of the good hybrids is so striking as to lead all observers to raise at once the question of establishing a hybrid stock as a substitute for the pure Egyptian. At the same time it has to be admitted that there is nothing to warrant the hope of practical success in this direction. The diversity among the hybrids is too great and experiments have not yet shown that uniformity can be secured, even by many generations of selective breeding.

Nevertheless, another possibility of utilizing hybrids in the production of cotton of very high grade remains to be considered. Experiments with crosses between Egyptian cottons and Central American varieties belonging to the Upland series have shown that the lint of first generations of hybrids is superior to that of the subsequent generations and very much more uniformly good in the individual plants. These facts suggest that a culture based on first generation hybrids might have better prospects of practical success than the attempt to

develop hybrid stocks. With a type of cotton so different from the Egyptian as the Kekchi, it would not be difficult to produce first generation hybrids on a commercial scale. The small size of the Kekchi plants and their broad-lobed hairy leaves would enable them to be separated very readily from the more robust and smoother hybrid plants, so that only hybrids need be allowed to grow to maturity.

The quality and uniformity of the crop might be still further guarded, if necessary, by selection in the field, for the larger size and greater fertility of the hybrid plants would make field selection very easy and expeditious. Indeed, such field selection of lint would involve much less difficulty than the careful selection of seed plants required to maintain the superiority of any carefully tried variety of cotton like the Sea Island or Egyptian.

The most serious objection to the staple furnished by the hybrids is that it usually lacks the brownish tinge, which is one of the commercial characteristics of most of the grades of Egyptian cotton that are imported into the United States. If this feature is important enough to make a difference in the price it may be possible to obtain darker hybrid lint by using a brown strain of the Kekchi cotton as the female parent of the hybrids.

Observations made by Mr. Kearney upon hybrids between the Egyptian cotton and several varieties of the Upland series appear to indicate that such crosses have less uniformity in the seed characters in the first generation than has been obtained in our experiments with the Kekchi cotton. Thus, of 280 Egyptian-Upland hybrids recorded at Yuma 124 had smooth seeds, while 156 had fuzzy seeds. No such proportion of smooth seed has been noted in the Kekchi-Egyptian hybrids, where smooth seeds are very rare in the first generation.

It has been noted already that smooth-seeded hybrids often have weak lint, whereas fuzzy-seeded hybrids, like those formed with the Kekchi cotton, generally have strong lint. Even when the lint becomes short or sparse it usually remains very strong. Fuzzy-seeded hybrids with weak lint were not noticed in the field at Sacaton, but Mr. Kearney's records show a case of this kind from Yuma. The character of the very fuzzy seeds of the Kekchi cotton seems to be much more strongly prepotent in hybrids with the Egyptian cotton than the corresponding character of the Upland varieties, though the presence of smooth seeds in some of our Upland types may help to explain this apparent difference.

PRINCIPAL CHARACTERS FOR DISTINGUISHING HYBRIDS.

For practical purposes it is possible to give a list of several characters which are sufficiently definite to serve as guides in eliminating

hybrids. Any one of these characters affords a sufficient ground for rejecting a plant as a hybrid, but in addition to the plants which may be recognized by these characters it will be good policy, in the interest of maintaining a pure stock, to reject any individual that shows a notable difference from its neighbors either in habits of growth or in any definite detail of form or color of foliage, flowers, bolls, seeds, or lint.

Breeders may have more difficulty than practical farmers in discarding hybrids. The farmer who is interested only in keeping his stock pure can at once rogue out any unusual plant, while the breeder will need to be very careful to avoid the danger of discarding a valuable sport on a mere suspicion that it may be a hybrid.

Following is a list of the most obvious and reliable characters for distinguishing hybrids:

- (1) Cordate, hairy, involucre bracts, with numerous (12 to 14) teeth.
- (2) Large, cup-shaped, white flowers, with pale petal spots or no spots at all.
- (3) Large pea-green bolls.
- (4) Bolls with five locks or a large percentage of bolls with four locks (25 per cent or upward).
- (5) Densely fuzzy, large seeds.
- (6) Hairy leaves, leaf stems, or branches.
- (7) Calyx with triangular pointed lobes.

CORRELATIONS OF CHARACTERS IN HYBRIDS.

An effort was made to detect correlations of characters in the hybrids as a further means of deciding the question of hybridity in doubtful cases. If in all plants known to be hybrids or definitely recognizable as such a character were always found to be combined with some other character, there would be less reason to believe that a plant was a hybrid when only one of these characters appeared. Such correlations might assist in determining whether any particular plant represented a first generation hybrid or a later generation, for the study of other cotton hybrids has shown that fairly definite correlations may appear in the first generations which are broken up in later generations.^a

In first generation hybrids between Egyptian cotton and the Kekchi cotton of Guatemala the seeds are almost always larger than those of either parent and these larger seeds are always covered with very dense bright-green fuzz. In later generations this grouping of characters is broken up. The seeds return to normal size and the green fuzz tends to disappear, giving place to the white fuzz of the

^a That external conditions may also have a notable influence upon the expression of characters in hybrids has been shown in a previous report, "Suppressed and Intensified Characters in Cotton Hybrids," Bulletin 147, Bureau of Plant Industry, U. S. Department of Agriculture. 1909.

Kekchi parent or to the naked black seed of the Egyptian parent. Whether because the Egyptian is the female parent in the present hybrids or because the fuzzy character of the Upland cotton is less prepotent than that of the Kekchi cotton the coordination of seed characters appears not to be so definite.

Nevertheless, it appears to be possible to group a large proportion of the hybrids into a few series characterized by fairly definite complexes of characters. All that can be claimed for the present is a probability that the different combinations of characters stand in fairly definite relations to fertility and lint production. As a basis for further study of the subject, brief descriptions of a few of the principal types have been drawn.

SYNOPSIS OF PRINCIPAL TYPES OF HYBRIDS.

The following are the principal types of hybrids:

- (1) Limbs stiff, erect, very upright, with short internodes; bolls small and lint inferior.
- (2) Limbs upright, somewhat spreading, with long internodes; bolls large, 3-locked, 4-locked, and sometimes 5-locked; lint abundant and usually long.
- (3) Limbs spreading, main axis generally strong and erect; bracts broadly cordate; flowers pale; bolls of Egyptian type; lint usually buff and like Egyptian in quality.
- (4) Plants lower and more spreading or prostrate, with long internodes; bolls numerous, 4-locked and 5-locked; lint long; seed well linted.
- (5) Plants of Upland habit of growth; bolls mostly 4-locked and 5-locked; seed usually large and fuzzy; lint abundant, but short.

TYPE I OF HYBRIDS.

The plants of Type I are tall and strictly upright. The basal limbs equal or exceed the main stem in length, are stiffly erect, and make a compact growth. The leaves are generally large, not deeply lobed, and often wrinkled or bullate. The fruiting branches are slender, short, and infertile, and usually bear only one or two small bolls with only a few seeds. The lint is short and very sparse, and covers only a small area at the upper end of the seed. The bracts are broad, deeply cordate, with rather short but narrow laciniae. The flowers are pale, with faint petal spots or none at all. These might be called "degenerate hybrids."

TYPE II OF HYBRIDS.

Type II is distinguished by excessive vegetative growth, long internodes, large five-lobed leaves, long ascending fruiting branches, and broad, cordate bracts of the Upland type. The plants may be either very productive or nearly sterile. The bolls are long and pointed like Egyptian, but are mostly four-locked and much larger

than Egyptian, and differ further in their pale pea-green color. The seeds are large and well covered with rather long lint, which is usually longer and less abundant on smooth than on fuzzy seeds. The flowers are larger than in Egyptian, petals pale yellow, and their basal spots faint. The filaments of the stamens are long, as in Upland, and the stigma is often shortened, protruding only slightly beyond the long stamens. The calyx is shorter than Egyptian and sharply lobed like Upland cotton.

Three forms of plants might be distinguished in this type, differing in the development of the basal branches as compared with the main axis:

(1) The first class has short, weak, spreading, basal limbs, but a very strong, upright, main axis. Sometimes late in the season primary limbs develop from the main axis near the top of the plant and bear branches.

(2) The second class differs from the first only in having two or three longer, more upright basal limbs. These first two types have strongly developed fruiting branches and are very productive.

(3) The third type has several very strong limbs, as long as the main axis. The fruiting branches are weak and bear few bolls.

TYPE III OF HYBRIDS.

Of the five types of hybrids Type III is the most like Egyptian. The plants are Egyptian in form, having the strong, slightly spreading basal limbs as long as the main axis. The bolls are three-locked and dark green. The lint is buff. The hybrid plant is distinguished from the Egyptian mainly by its larger size, broad, cordate bracts, and rather pale flowers. The bolls are enlarged and the seeds are large and generally fuzzy. Such plants are usually infertile.

TYPE IV OF HYBRIDS.

Type IV includes the most productive and the most abundantly linted plants in the hybrid series. The plants are more spreading than the Egyptians, having a strong main axis with long, widely spreading or prostrate basal limbs. The fruiting branches are horizontal. All internodes are long. The leaves are rather large, five-lobed, and generally hairy on the lower surface. Other distinguishing features are broad, cordate bracts, faint petal spots, a predominance of large, four-locked and five-locked bolls, and large seeds. The lint is abundant and fine; smooth seeds bear a longer staple than fuzzy seeds. Most of the plants have red stems, but a few green-stalked plants occur. Some of the plants are more upright or more compact than others, but apart from these slight differences there is a very consistent agreement in characters, often extending to minute particulars.

TYPE V OF HYBRIDS.

The fifth type includes the small Upland-like plants which can be easily detected as hybrids by their small size and hairy Upland-like leaves. Only the main axis and the fruiting branches are developed to any extent, the basal limbs being suppressed or remaining short and spreading. The bolls are large, four-locked and five-locked, light green, and with shallow gland pits. The seeds are large and usually fuzzy, with abundant, rather short, but often fine lint. The flowers are as light as Upland, with either faint or dark spots, very large anthers, cream-colored or whitish pollen, and stigmas protruding only slightly, if at all, beyond the stamens.

CONCLUSIONS.

The general practical conclusions regarding the nature and causes of diversity have already been stated in the introduction as the best means of indicating to the reader in advance the point of view from which our studies were made.^a The following paragraphs constitute a somewhat more detailed summary of the facts that have been established, with indications of their bearings upon the problems to be solved and methods to be used in this and other similar investigations.

The Egyptian and Upland cottons belong to the same general series of American types and are capable of showing similarly wide ranges of diversity, especially when grown under new and unwonted conditions. This community of origin and parallel behavior warrants a tentative application to the Egyptian cotton of facts and principles learned in the study of the acclimatization of tropical American cottons in the United States.

Studies of Egyptian varieties grown at Yuma from imported seed show many forms of diversity that would not be expected to appear in carefully selected varieties and would usually be ascribed to hybridization. In the plantings of Arizona-grown Egyptian seed this diversity appears to have increased rather than to have diminished, even after the exclusion of all individuals that can be distinguished as hybrids.

The difficulty of acclimatizing Egyptian cotton is increased by the fact that the varieties have been distinguished thus far by lint characters alone, with little or no reference to the vegetative features. Selection for long lint has not reduced the diversity of forms, and

^a The practical aspects of the experiments with Egyptian cotton in the season of 1908 have been treated by Messrs. Kearney and Peterson in Circular No. 29 of the Bureau of Plant Industry, published April 16, 1909.

the crossing of these varied forms with each other tends to prolong the condition of diversity instead of hastening the completion of acclimatization.

To secure prompt acclimatization, selection should have reference to the normal behavior of the plants rather than to new characters or to special excellence in particular characters. Acclimatization is to be distinguished both in aims and in methods from the selective breeding by which new and improved varieties are obtained.

Incomplete acclimatization renders the plants unusually susceptible to differences of external conditions. Different parts of the same field often show serious differences in the fertility of the plants, as well as in the length, strength, and abundance of the lint. These discrepancies appear out of proportion to the differences in the conditions as shown by the size and vegetative vigor of the plants, but can be understood if we remember that fertility and early bearing depend upon the habits of branching which the individual plants may adopt and that such habits are readily influenced by external conditions.

Additional diversity is occasioned by the appearance in the Egyptian fields of numerous hybrids between the Egyptian cotton and the Upland. The presence of so many hybrids is explained by the fact that the cotton flowers at Yuma are visited by insects which are apparently more numerous and active than at any other points where cotton experiments have been described, either in the United States or in foreign countries. Such insects will render it practically impossible to maintain pure stocks of Egyptian seed if Upland cotton is grown in the same localities.

Hybrid plants, at least in the first generation, are usually more fertile than the pure Egyptian plants and produce longer and stronger lint. In spite of the diversity of vegetative characters among the hybrids their lint is commonly more uniform in length and strength than that of the pure Egyptian plants, though distinctly different from the pure Egyptian fiber. In later generations of hybrids degenerate plants occur, infertile and inferior in lint.

The very high grades of lint that may be obtained from first generation hybrids and their extreme vigor and productiveness warrant the consideration of means for obtaining hybrid seed in commercial quantities. A possibility of producing fields of hybrid plants lies in the fact that certain of the characters of Egyptian cotton are strongly prepotent, especially in the first generation. Thus, if the Egyptian were crossed on the small Kekchi type of Upland cotton the young hybrid plants could readily be distinguished from the Kekchi plants and the latter removed in the process of thinning the seed-

lings. To recognize the young hybrids among Egyptian seedlings would be much more difficult, if not actually impossible.

This possibility of utilizing hybrids should not be allowed to obscure the fact that hybrids are a distinct disadvantage in fields of Egyptian cotton because they interfere with the uniformity of the lint. The elimination of hybrids is rendered very difficult by the fact that many of them show no perceptible differences in their vegetative characters and habits of growth to distinguish them from the pure Egyptian plants before the involucre and floral buds have developed. Nevertheless, it is necessary that the hybrids be eliminated as soon as they begin to flower; otherwise their pollen will infect the next generation. To reject the seed of hybrid plants does not completely purify an Egyptian stock that has once been hybridized.

The preceding considerations make it evident that Upland cotton must either be excluded from regions when Egyptian cotton is to be grown, or local sources of supply of pure, acclimatized Egyptian seed must be established and very carefully guarded from contact with Upland cotton if commercial cultures of Egyptian cotton are to be permanently maintained in Arizona and the neighboring States. Even if a culture based on hybrids should prove feasible it would still be essential to maintain pure stocks of the parent types to continue the production of the hybrid seed.

The diversity in the behavior of Egyptian cotton at the different places where it was grown this year shows that it may not suffice to complete the process of acclimatization in any one locality if this seed is to be planted afterwards in any other localities. It should not be supposed that the possibilities of growing Egyptian cotton in a new locality can be judged from a single planting. Even after acclimatization has been completed and the industry established, it will still be necessary to take into account the need of adjustment to local conditions whenever the crop is to be extended to a different district.

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DESCRIPTION OF PLATES.

The illustrations used for these plates were furnished by Mr. Kearney. The photographs were taken at Yuma, Ariz., at the end of the season (October 7-13, 1908), when the plants were fully mature.

PLATE I. Fig. 1.—Egyptian cotton. An acclimatized plant showing the form taken when a strong central stalk is developed. Vegetative branches rather small; fruiting branches large. Fig. 2.—Egyptian cotton. A plant from newly imported seed showing the form taken when there is a strong development of the vegetative branches. Fruiting branches small and unproductive; no fruit on lower half of plant.

PLATE II. Fig. 1.—Egyptian cotton. A plant showing an intermediate development of branches, the central stalk and vegetative branches both bearing numerous fertile branches. Fig. 2.—Egyptian cotton. A large and very fruitful plant bearing more than 300 bolls. Branches equal to main stem, but likely to be bent or broken to the ground by the weight of the fruit.

PLATE III. Fig. 1.—Egyptian-Upland cotton hybrid. A small plant with the habit of growth of Upland cotton. Bolls pea-green in color, borne mostly near the bottom of the plant, smaller than usual in hybrids; lint very abundant. This plant represents the fifth type of hybrids. Fig. 2.—Egyptian-Upland hybrid. A tall, vigorous, fertile plant, showing long fruiting branches and greater fertility at the base of the plant; also showing Upland features of pea-green bolls and green fuzzy seeds. This plant represents the second type of hybrids.

PLATE IV. Egyptian cotton, Mit Afifi variety, grown from newly imported seed. Bracts and bolls from several different plants to show range of difference in shape and markings. The bracts show the typical Egyptian form with the three middle teeth somewhat abruptly prominent. The calyx of the boll with the bracts is split and is not to be confused with the lobes of the calyx of the hybrid shown in the next plate. (Natural size.)

PLATE V. Mature unopened bolls of first generation hybrid of Egyptian and Upland cottons at Yuma. The larger size, more pyramidal shape, smaller and more shallow pits, and pea-green color afford ready distinctions. (Natural size.)

PLATE VI. Fig. 1.—Flower from an Egyptian plant and a flower from a hybrid plant, showing a broader and more cup-shaped, shorter corolla. Fig. 2.—Staminal columns of Egyptian flowers, with short filaments and long styles. Fig. 3.—Staminal columns of hybrid flowers, showing the longer filaments and shorter, thicker styles characteristic of the hybrids. (Natural size.)



FIG. 1.—FERTILE PLANT OF EGYPTIAN COTTON, SHOWING STRONG CENTRAL STALK AND LONG FRUITING BRANCHES.



FIG. 2.—PLANT OF UNPRODUCTIVE TYPE OF EGYPTIAN COTTON, SHOWING NUMEROUS VEGETATIVE BRANCHES AND VERY SMALL FRUITING BRANCHES.



FIG. 1.—MODERATELY PRODUCTIVE PLANT OF EGYPTIAN COTTON, WITH BOTH VEGETATIVE AND FRUITING BRANCHES WELL DEVELOPED.



FIG. 2.—VERY PRODUCTIVE EGYPTIAN COTTON PLANT, WITH ABUNDANT FRUITING BRANCHES.



FIG. 1.—EGYPTIAN-UPLAND HYBRID. A SMALL PLANT OF THE UPLAND TYPE.

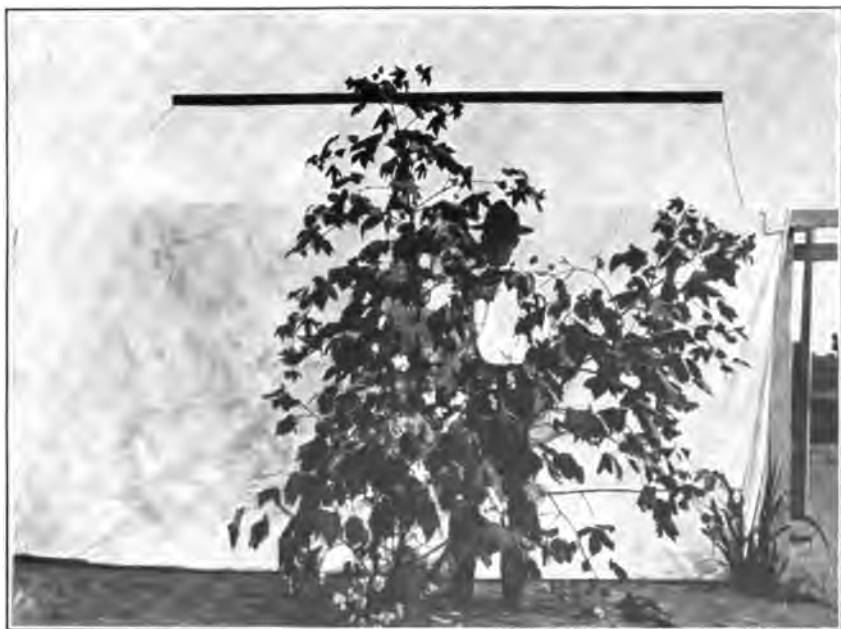


FIG. 2.—EGYPTIAN-UPLAND HYBRID. A MODERATELY LARGE AND FERTILE PLANT.



BOLLS AND INVOLUCRAL BRACTS OF MIT AFIFI EGYPTIAN COTTON GROWN IN ARIZONA.
(Natural size.)



**BOLLS AND INVOLUCRAL BRACTS OF EGYPTIAN-UPLAND HYBRID COTTON WITH
STRONG RESEMBLANCE TO UPLAND PARENT.**

(Natural size.)



FIG. 1.—FLOWER OF EGYPTIAN COTTON AND FLOWER OF EGYPTIAN-UPLAND HYBRID.
(Natural size.)



FIG. 2.—STAMENS AND STIGMAS OF EGYPTIAN COTTON.
(Natural size.)



FIG. 3.—STAMENS AND STIGMAS OF EGYPTIAN-UPLAND HYBRIDS.
(Natural size.)

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